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NGA STANDARDIZATION DOCUMENT

Implementation Profile

for

High Resolution Elevation (HRE) Products

Specification of the data content, structure and metadata
for raster elevation data products

(2014-04-15)

Version 1.1

NATIONAL CENTER FOR GEOSPATIAL INTELLIGENCE STANDARDS

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Introduction

The Implementation Profile for High Resolution Elevation (HRE) Products describes the data content, structure and metadata requirements required to create a suite of raster elevation data products. These products are defined within this document as a set of spatial resolution layers and are named High Resolution Elevation (HRE) data. HRE data is intended for a wide variety of National Geospatial-Intelligence Agency (NGA) and National System for Geospatial Intelligence (NSG) partners and members, and customers external to the NSG, to access and exploit standardized data products. HRE data replaces the current non-standard High Resolution Terrain Elevation/Information (HRTE/HRTI) products and also replaces non-standard products referred to as DTED level 3 thru 6. This profile is not intended to replace standard DTED 0, 1 and 2 products which will continue to be supported by NGA.

The intent of this profile is to increase the level of interoperability with and between organizations producing and using topographic elevation data within the elevation community of interest. The elevation data described in this implementation profile is typically used for mission planning, terrain modeling and other related applications. Elevation data is often fused with other Geospatial products to provide enhanced visualization capabilities for analysts and mission planners.

1. Scope

The Implementation Profile for High Resolution Elevation (HRE) Products has been developed by NGA to support the requirement for a uniform, orthogonal grid-based geospatial elevation topographic model for a wide range of geospatial resolutions. The profile specifies the content, structure, and format for NGA gridded topographic (land) elevation datasets in support of data discovery, access, processing, exploitation, and exchange.

The Implementation Profile for High Resolution Elevation (HRE) Products is an integral part of the overall NGA elevation strategy to adopt a two-tiered architecture. This architecture enables storage and accessibility of native format high resolution data from a variety of sources that can then be used to create a suite of standard elevation product layers for the traditional geospatial customer. These standard products are addressed by this profile. This architecture will also enable customers within the NSG to access and exploit the native format data to create custom products for specific intelligence/application requirements. These custom products may or may not be addressed by this profile depending on the mission specific nature of the requirement.

This profile defines the elevation data content and structure, spatial resolution, format, accuracy and metadata for HRE data. HRE data share a common file format and encoding, common quality/accuracy definitions, as well as common metadata elements. The profile is designed primarily for a bare earth or reflective surface models. It does not address the design or implementation of a database to store native format data.

This profile is authored and maintained by NGA and will be reviewed on a periodic basis and updated in concert with advances in technology and subsequent advances in data sources and production capabilities.

2. Conformance

Any application or system claiming conformance for generating data in compliance with this implementation profile shall meet the following criteria for data conformance.

2.1. File Format

The data file format and structure is as specified by NITF version 2.1, and as further constrained by this profile. The data complies with the NITF version 2.1 compliance criteria specified in NGA document, N0105 - National Imagery Transmission Format Standard (NITFS) Standards Compliance and Interoperability Certification Test and Evaluation Program Plan, that pertain to the NITFS features, options and capabilities selected for use in this profile.

2.2. Completeness

All field values and data elements defined as mandatory (required) are present and populated with meaningful values as defined by the profile. All field values and data elements defined as conditional are present, and meaningfully populated, when the conditions described in the profile apply.

2.3. Maximum occurrence (all levels of obligation)

Each field value and data element occurs no more than the number of times specified.

2.4. Data Type (all levels of obligation)

The value of each provided field value and data element adheres to the data type specified.

2.5. Domain (all levels of obligation)

The values of each field value and data element fall within the specified domain.

2.6. Schema (XML-instance data only, all levels of obligation)

Each data element is contained within the specified schema entity.

Note 1: Minimum conformance requires that the supplemental metadata instance (XML) documents can be validated without error against the XML schemas defined by this profile. While many tools are available to test validation of XML instance documents against provided XML Schemas, it is important to understand that not all validation tools implement the full W3C XML Schema recommendation and not all validation tools interpret the W3C XML Schema recommendation in the same manner. It is recommended that a tool with strict interpretation of XML Schema and full support for the W3C XML Schema recommendation be used to ensure conformance.

Note 2: Validation of XML instance documents against the schemas described in this document is not all that is required for conformance to this profile. A property element is designed to have content (by-value) or attributes (by-reference or NULL with reason).
However, because of the design, the property element may have no content or attributes, or it may have both content and attributes and still be XML Schema-valid. It is not possible to constrain the co-occurrence of content or attributes. Some mechanism in addition to an XML Schema validation must be used to restrict a property to be exclusively by-value, or by-reference, or expressing a NULL reason.

Note 3: XML Schema does not support the enforcement of certain types of constraints documented in this profile. For example, conditional constraints to force selection of one or more items from a list of optional items are not always enforceable within XML schema. Neither are co-constraints enforceable such as requirements to include elements based on values contained in other elements. These conditions must be evaluated through inspection.

2.7. Horizontal Accuracy

Datasets conform to the predefined thresholds (Tables 8-1 and 8-2) for horizontal accuracy. An absolute horizontal accuracy estimate is reported for each dataset.

2.8. Vertical Accuracy

Datasets conform to the predefined thresholds (Tables 8-3 and 8-4) for vertical accuracy. An absolute vertical accuracy estimate is reported for each dataset.

2.9. Production Specific Guidance

When production specific guidance is provided, dataset content complies with the provisions of the guidance.

3. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NGA.STND.0012-1_2.1 National System for Geospatial Intelligence Metadata Foundation (NMF) Part 1: Core, 26 March 2012
NGA.STND.0012-3_1.0.0 National System for Geospatial Intelligence Metadata Foundation (NMF) Part 3: Metadata for Imagery and Gridded Data, 31 July 2012
NGA.STND.0033_1.0 Geopolitical Entities, Names and Codes Standard, Version 1.0
NGA.IP.0008_1.0 The Universal Lidar Error Model (ULEM): Implementation and Exploitation, 2013-01-22, Version 1.0
MIL-STD-2500C National Imagery Transmission Format Version 2.1
STDI-0002-1_4.0 Compendium of Controlled Extensions for the National Imagery Transmission Format (NITF) Volume 1, Tagged Record Extensions
STDI-0002-2_4.0 Compendium of Controlled Extensions for the National Imagery Transmission Format (NITF) Volume 2, Data Extension Segments
ISO 19107:2003 Geographic information – Spatial schema
ISO 19115:2003 Geographic information - Metadata
ISO 19115-2:2008 Geographic information - Metadata: Extensions for imagery and gridded data
ISO 19123:2005 Geographic information - Schema for coverage geometry and functions
DGIWG 116-1 Defence Geospatial Information Working Group Elevation Surface Model Standardized Profile, Version 1.0.1

4. Terms and definitions

4.1. Terms and definitions

4.1.1. Absolute Horizontal Accuracy

Statistical evaluation of all random and systematic errors encountered in determining the horizontal position of a single data point with respect to a specified geodetic horizontal reference datum, expressed as a circular error at the 90 percent probability level (CE90). [adapted from DMA-TR-8400.1].

4.1.2. Absolute Vertical Accuracy

Statistical evaluation of all random and systematic errors encountered in determining the elevation of a single point with respect to a vertical reference datum, expressed as a linear error at the 90 percent probability level (LE90). [adapted from DMA-TR-8400.1].

4.1.3. Accuracy

Closeness of agreement between a test result and the accepted reference value.

[ISO19113]

4.1.4. Continuous Coverage
Coverage that returns different values for the same feature attribute at different direct positions within a single spatial object, temporal object, or spatiotemporal object in its domain.
[ISO 19123]

4.1.5. Coordinate
One of a sequence of numbers designating the position of a point in N-dimensional space.
[ISO 19111]

4.1.6. Coordinate Reference System
Coordinate system which is related to the real world by a datum.
[ISO 19111]

4.1.7. Coverage
A feature that acts as a function to return values from its range for any direct position within its spatial, temporal, or spatiotemporal domain.
[ISO 19123]

Examples include a digital image, polygon overlay, or digital elevation matrix.

NOTE: In other words, a coverage is a feature that has multiple values for each attribute type, where each direct position within the geometric representation of the feature has a single value for each attribute type.

4.1.8. Data Compression
Compression reduces the amount of storage space required to store a given amount of data, or reducing the length of message required to transfer a given amount of information.
[ANS T1.523-2001]

4.1.9. Dataset
Identifiable collection of data.
[ISO 19115:2003]

4.1.10. Direct Position
Position described by a single set of coordinates within a coordinate reference system.
[ISO 19107]

4.1.11. Elevation
Distance measured along a plumb line between a point and the geoid, upward is positive (+), downward is negative (-).

NOTE The elevation of a point is normally the same as its orthometric height. This is the "official" geodesy definition of elevation, but the term "elevation" is also used more generally for height above a specific vertical reference, not always the geoid.

4.1.12. Feature
Abstraction of real world phenomena.

[ISO 19101]

4.1.13. Feature Attribute

Characteristic of a feature.
[ISO 19109]

NOTE: A feature attribute type has a name, a data type and a domain associated to it. A feature attribute instance has an attribute value taken from the value domain of the feature attribute type.

4.1.14. Geometric Object

Spatial object representing a set of direct positions.
[ISO 19107]

NOTE: A geometric object consists of a geometric primitive, a collection of geometric primitives, or a geometric complex treated as a single entity. A geometric object may be the spatial characteristics of an object such as a feature or a significant part of a feature

4.1.15. Grid

Network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in a systematic way.
[ISO 19123]

NOTE: The curves partition a space into grid cells.

4.1.16. Grid Point

Point located at the intersection of two or more curves in a grid.
[ISO 19123]

4.1.17. Height

Distance of a point from a chosen reference surface measured (upward +, downward -) along a line perpendicular to that surface.

NOTE: Height is distinguished from elevation in that it is a directional measurement.

4.1.18. Point

0-dimensional geometric primitive, representing a position.
[ISO 19107]

4.1.19. Predicted Error

Measure of the likely error at a point, often assumed (but not required) to be normally distributed in nature and often provided as a variance (1-D case) or covariance matrix (otherwise).

4.1.20. Random Error

Random errors are those not classified as blunders, systematic errors, or periodic errors. They are numerous, individually small, and each is as likely to be positive as negative. [MIL-HDBK 850]

4.1.21. Random Horizontal Error

Combination into a 2D error of variations remaining observable in the x and y components of the HRE dataset after blunders, biases, and systematic errors have been accounted for.

$$Random\ HE = \left[\left(\left(X_{meas} - \mu_{\Delta X} \right) - X_{true} \right)^2 + \left(\left(Y_{meas} - \mu_{\Delta Y} \right) - Y_{true} \right)^2 \right]^{1/2}$$

4.1.22. Random Vertical Error

Variations remaining observable in the vertical component of the HRE dataset after blunders, biases, and systematic errors have been accounted for.

$$Random\ VE = \left(Z_{meas} - \mu_{\Delta Z} \right) - Z_{true}$$

4.1.23. Record

Finite, named collection of related items (objects or values).
[ISO 19107]

NOTE: Logically, a record is a set of pairs <name, item >.

4.1.24. Relative Accuracy

Evaluation of the random errors in determining the position of one point or feature with respect to another.
[adapted from MIL-HDBK 850]

4.1.25. Relative Horizontal Accuracy

Statistical evaluation of all random errors encountered in determining the horizontal position of one data point with respect to another , expressed as a circular error over a specified distance at the 90 percent probability level. [adapted from DMA-TR-8400.1]

4.1.26. Relative Vertical Accuracy

Statistical evaluation of all random errors encountered in determining the elevation of one data point with respect to another, expressed as a linear error over a specified distance. [adapted from DMA-TR-8400.1]

4.1.27. Tessellation

Partitioning of a space into a set of conterminous geometric objects having the same dimension as the space being partitioned.
[ISO 19123]

4.1.28. Vector

Quantity having direction as well as magnitude.
[ISO 19123]
NOTE: A directed line segment represents a vector if the length and direction of the line segment are equal to the magnitude and direction of the vector. The term vector data refers to data that represents the spatial configuration of features as a set of directed line segments.

4.2. Symbols and abbreviated terms

CE90 – Circular Error measured at the 90% confidence interval.

DEM – Digital Elevation Model

DSM – Digital Surface Model

DTEM – Digital Terrain Elevation Model

EGM - Earth Gravitational Model

ETS – Executable Test Suite

HRE – High Resolution Elevation data

HREGP – High Resolution Elevation Geographic Projection
(see Section 5.4)

HRE80-HRE01 – High Resolution Elevation Universal Transverse Mercator Projection
(see Section 5.4)

LE90 – Linear Error measured at the 90% confidence interval.

LSB – Least Significant Bit

MSB – Most Significant Bit

MSL – Mean Sea Level

NITF – National Imagery Transmission Format

UTM - Universal Transverse Mercator coordinate system

WGS-84 – World Geodetic System 1984

5. Data Content and Structure

The High Resolution Elevation (HRE) data structure is a uniform, orthogonal grid-based geospatial elevation topographic model. The Implementation Profile for High Resolution Elevation (HRE) Products supports a wide range of geospatial resolutions. The profile supports geographic (HREGP) and Universal Transverse Mercator projections (HRE80-HRE01), multiple spatial resolutions, and multiple elevation data coverages where the various coverages allow for different surface classifications, such as reflective surface or bare earth.

5.1. Grid Structure

A grid structure is the most common geospatial data model used for modeling topographic elevation data. The HRE grid structure is represented by a collection of regularly or uniformly spaced points as shown in Figure 5.1. This structure provides several advantages over other types of elevation geospatial data models in that a regular spacing of elevation points requires that only one elevation point be referenced to a horizontal coordinate. From this one point and its horizontal coordinate value and the ground sampling distance (GSD) between grid elevation points, the horizontal coordinate values of all other points can be determined. This eliminates the need to explicitly define the horizontal coordinate values of each elevation point and helps to minimize file size. The grid structure is also an efficient structure for data processing.

Within a HRE dataset, only one grid spatial resolution will be represented. The grid point locations for each elevation value are fixed within the coordinate system. The minimum grid sampling distance (see Table 5.1 and Table 5.2) should be chosen to most efficiently represent the resolution of the source native dataset. Grids may not model all terrain features smaller or narrower than the grid spacing when the feature lies between grid points.

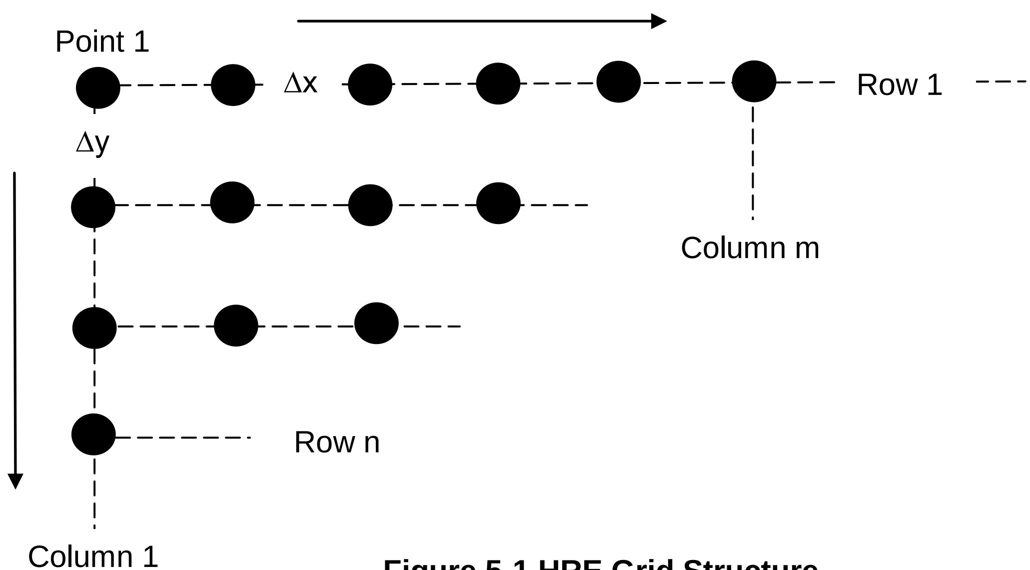


Figure 5-1 HRE Grid Structure

HRE grid records are structured in row major order such that the sequential order of the data within each record comprises a row of data for which the horizontal coordinates of each elevation point for that row has the same northing coordinate value. The records are sequenced north to south (1 to n) by a distance Δy, such that the first record in the dataset is the northern most row and subsequent records are the rows sequentially ordered to the south. The first elevation point value in a record is the western most elevation point for that row / record with subsequent elevation point values progressing west to east a distance Δx. The last elevation point value in the dataset is the elevation point in the southeastern most location. See Figure 5.1 – HRE Grid Structure.

5.2. Grid Point Coordinate locations

HRE grid points are 0-dimensional geometric primitives representing a coordinate location that is defined by the intersections of the curves that make up the grid.

HRE grid point coordinate locations shall adhere to a set of predefined elevation point locations within the horizontal coordinate reference system. This is to ensure points from different datasets with overlapping horizontal spatial extents are horizontally coincident.

5.2.1. Geographic Point Locations

For geographic data the predefined reference origin is the elevation point at the southwest corner elevation point of the one degree cell in which the southwest corner of the HREGP data is located. The origin must be evenly divisible by the GSD to ensure alignment between datasets. If the point spacing is specified as {Δφ, Δλ } and the southwest corner of dataset with which it is associated is {φ, λ} then point location coordinates will be defined at {φ+ j*Δφ, λ+ i*Δλ} [NOTE: the data are stored in row/column order] The values i and j are integer values of points in the Longitude and Latitude direction (respectively), +i*Δλ signifies an easterly direction from the origin and +j*Δφ signifies a northerly direction from the origin. See Figure 5.2 – Example of geographic projected point locations.

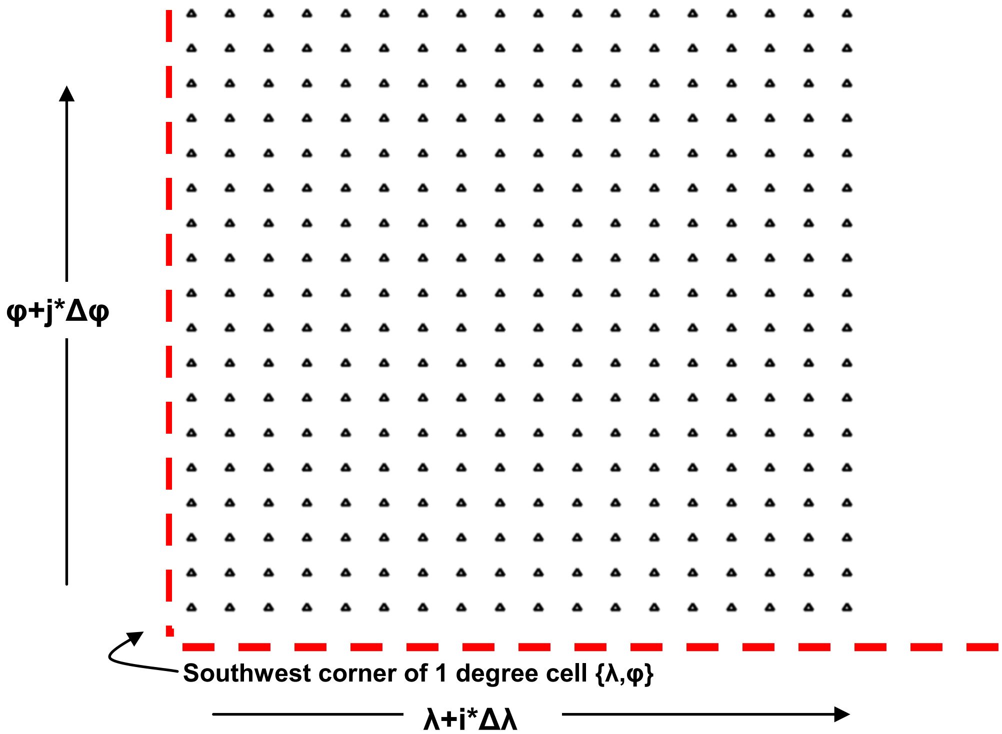


Figure 5-2 Example of Origin and Point Locations for Geographic Data

5.2.2. UTM Point Locations

For a HRE data file, the reference origin for UTM products will be the origin of the UTM zone in which the HRE data is located. UTM zone origins are specified by the intersection of the UTM zone central meridian with the equator. This intersection is assigned the UTM coordinates 500000.0 E, 0.0 N for zones in the northern hemisphere and coordinates 500000.0 E, 10000000.0 N for zones in the southern hemisphere. If the point spacing of a given HRE level is specified as {ΔE, ΔN}, then points for a HRE Level in the Northern hemisphere will be defined at {500000± i*ΔE, 0+ j*ΔN}. The values i and j are integer values of points in the Easting and Northing direction (respectively), +i*ΔE signifies an easterly direction from the central meridian, -

i*ΔE signifies a westerly direction from the central meridian, and +j*ΔN signifies a northerly direction from the equator. In a similar fashion, points in the Southern hemisphere are specified by {500000± i*ΔE, 10000000- j*ΔN}, where i and j are integer values of points in the Easting and Northing direction (respectively),+i*ΔE signifies an easterly direction from the central meridian, -i*ΔE signifies a westerly direction from of the central meridian, and -j*ΔN signifies a southerly direction from the equator [NOTE: the data are stored in row/column order – see B.1.8]. Adhering to this system will assure that coincident points are maintained across the various HRE levels within a zone. This will allow for direct comparison between datasets and direct decimation of high-resolution data to lower resolutions. See Figure 5.3 Example of UTM Point Locations in Northern Hemisphere

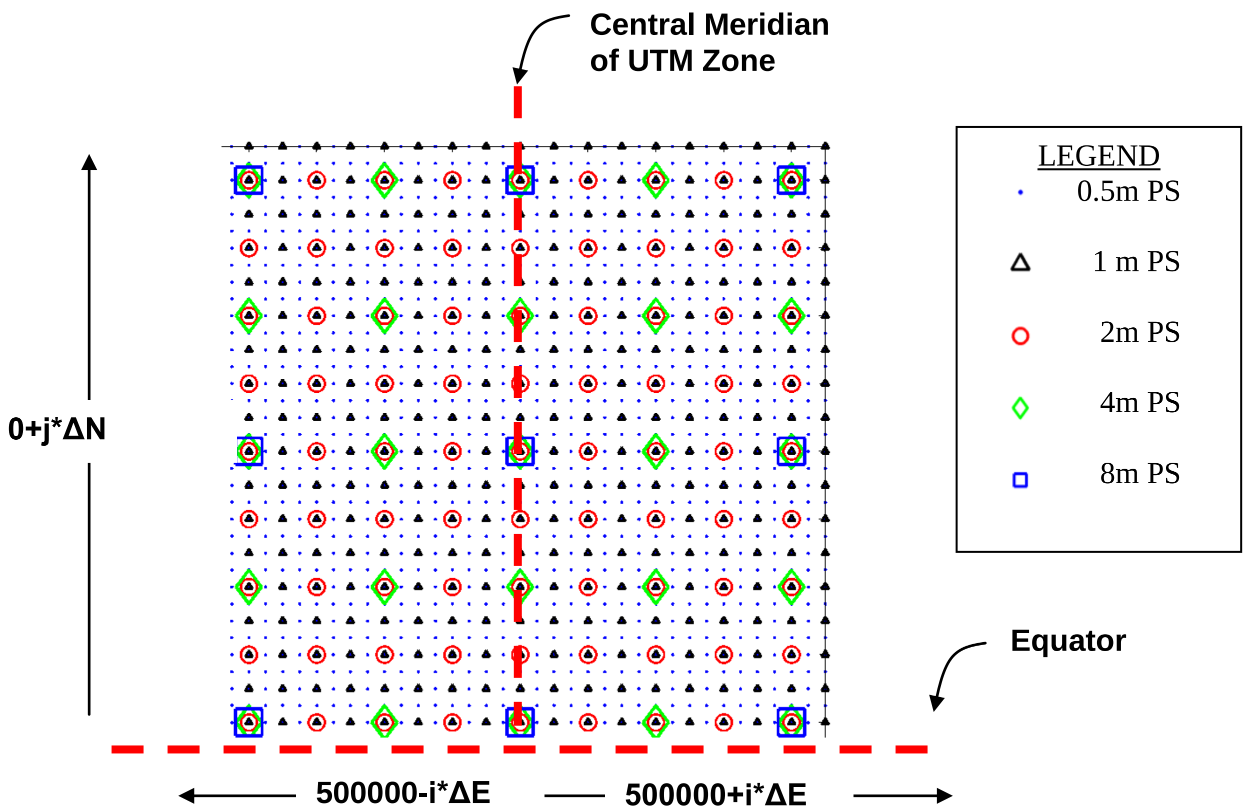


Figure 5-3 Example of UTM Point Location In Northern Hemisphere

Note that the various symbols represent different HRE levels, but illustrate collocated points.

5.3. Product Name/Level:

HRE data Product Names and Levels are associated with the dataset projection and spatial resolution. Table 5.1 identifies the 8 HRE levels and the associated product name.

5.4. Horizontal Spatial Extent and Projection

The horizontal spatial extent of HRE data vary based on a number of factors. These factors can include but are not limited to spatial resolution, geographic location, customer requirements and file size limitations (see Section 12.3 – File Size Estimates). Typically as the horizontal spatial resolution of the data set increases (points are closer together geographically) the horizontal spatial extent decreases in size.

- HREGP data are cast on a geographic projection and primarily cover large geospatial areas (nominally region sized). HREGP products are typically tiled (not do be confused with NITF blocks which are sometimes referred to as tiles) to allow them to be joined into these large area configurations. HREGP dataset horizontal and vertical values will be horizontally and vertically coincident at the dataset edges. That is, the adjacent HREGP product coincident points horizontal coordinates and vertical elevation values will be the same.

- HRE80-HRE01 data are cast on the Universal Transverse Mercator projection and primarily cover localized area dataset extents. HRE80-HRE01 datasets are designed to be spatially contained within a single UTM zone. Adjacent datasets within one UTM zone will be horizontally coincident at the dataset edge but adjacent dataset in adjacent UTM zones will not be horizontally coincident at the dataset edge. Vertical elevation values may (not required) match across HRE80-HRE01 levels for the same geographic area or elevation point.

5.5. Horizontal Spatial Resolution

HREGP datasets have a horizontal spatial latitudinal resolution of 0.4 arc-seconds and a varying longitudinal resolution of 0.4 to 2.4 arc seconds based upon latitude (see Table 5.2). HRE80-HRE01 datasets have 7 levels of spatial resolutions; where in ascending HRE level order, the spatial resolution of a particular level is twice that of the previous level and in descending HRE level order, half that of the previous level (see Table 5.1 HRE Level Point Spacing). This enables horizontal coordinates for elevation to be consistent across HRE Levels. For the sake of clarity, the product names will be used throughout this document to distinguish the differences among the levels.

Table 5-1 HRE Level Point Spacing

Level	Product Name	Horizontal Grid spatial resolution	Horizontal Units
1	HREGP	0.4	arc-seconds
2	HRE80	8	meters
3	HRE40	4	meters
4	HRE20	2	meters
5	HRE10	1	meters
6	HRE05	0.50	meters
7	HRE02	0.25	meters
8	HRE01	0.125	meters

With convergence of meridians in higher latitudes, the longitudinal arc-second point spacing of the HREGP product varies as a function of latitude and is defined in five zones of latitude shown below in Table 5-2 HREGP Point Spacing

Table 5-2 HREGP Point Spacing

Zone	Latitude Range in Degrees	Latitudinal grid point spacing (arc seconds)	Longitudinal grid point spacing (arc seconds)
1	00-50 North-South	0.40	0.40
2	50-70 North-South	0.40	0.80
3	70-75 North- South	0.40	1.20
4	75-80 North-South	0.40	1.60
5	80-90 North-South	0.40	2.40

6. Elevation Values and Units

HRE elevation values will contain valid elevation values and may contain null (no-data) values.

6.1. Valid Elevation values

Valid elevation point values exist in geographic areas where the elevation point value can be accurately determined. For grid points with valid elevations, the data type will be specified in the Pixel Value Type (PVTYPE) field in the HRE NITF Image Subheader. All numeric values are encoded in Most Significant Byte (MSB) first order known as the "big endian" convention.

- Valid elevation values for HREGP data shall be a signed 16 bit integer value. The PVTYPE value shall be SI (Signed Integer) designating that the data values are encoded using 2’s complement representation. The SI type indicates the data bits shall appear in the file in order of significance, beginning with the MSB and ending with the LSB.

- Valid elevation values for HRE80-HRE01 shall be a 32 bit floating point value. The PVTYPE value shall be R. The data values shall be represented according to IEEE 32-bit floating point representation (IEEE-754).

6.2. Null Values

Null (No-Data) values are used for geographic areas when the elevation point values cannot be accurately determined due to various factors, often related to source anomalies, metrological or topography related conditions. Reasons for Null Values may be because of image cloud cover, shadows or obscuration due to topographic conditions. The Null value, when used, will be specified in the NITF Image Data Mask Table, Pad Output Pixel Code (TPXCD) field in the HRE NITF Image Subheader for Elevation Data.

- Null values for HREGP data will be a signed 16 bit integer value encoded as hexadecimal 0x8001, decimal -32767.

- Null values for HRE80-HRE01 data will be an IEEE-754 floating point value encoded as hexadecimal 0xFFFFFFFF. This value is not in the range of valid IEEE-754 floating point numbers and is known as "Not a number" (NaN).

6.3. Vertical Units of Measure

The vertical unit of measure for HREGP elevation points shall be integer meters. The vertical unit of measure for HRE80-HRE01 shall be decimal meters. The unit of measure code 'M' will be specified in the Band Subcategory (ISUBCAT01) field in the HRE NITF Image Subheader.

7. Reference Datums

7.1. Horizontal Reference Datum

The Horizontal reference datum for HRE data shall be the World Geodetic System - WGS-84 and the specific epoch will be identified in metadata.

7.2. Vertical Reference Datum

The baseline vertical reference datum for all HRE data stored at NGA will be ellipsoid height as defined by WGS-84. HRE data may optionally be distributed to customers referenced to the current Earth Gravitational Model (EGM) implementation of WGS-84. Metadata will be populated to indicate the vertical reference system.

8. Data Quality

HRE data quality characteristics are defined by five factors: (1) point spacing, (2) random horizontal error per point, (3) relative horizontal accuracy between points, (4) random vertical error per point, and (5) the relative vertical accuracy between points. Additionally, goal levels for absolute horizontal and vertical accuracy have been established. The specifics of these accuracy requirements are provided in the following sections. Optional accuracy information for per point and regional error estimates are also provided in Section 14.4

8.1. Horizontal Accuracy:

HRE elevation datasets shall conform to the predefined thresholds for horizontal accuracy. Randomly selected datasets may be tested to assure that the random horizontal error per point and relative horizontal accuracy between points meets or exceeds the thresholds detailed in

Table 8-1 and Table 8-2. Additionally, there is a goal that the absolute horizontal accuracy meet or exceed the values established in Table 8-1 HREGP Horizontal Accuracy Requirements and Table 8-2 HRE80-HRE01 Horizontal Accuracy Requirements. Although not required to meet a threshold requirement an absolute horizontal accuracy estimate will be reported for each data set.

Table 8-1 HREGP Horizontal Accuracy Requirements

Product name	Spatial resolution in arc seconds	Random Horizontal Error Per Point (σ_H – meters)	Relative Horizontal Accuracy Between Points (R_h – meters)	Goal: Absolute Horizontal Accuracy CE90 (meters)
HREGP	0.4	4.4	12.4	15.0

Table 8-2 HRE80-HRE01 Horizontal Accuracy Requirements

Product Name	Grid spatial resolution in meters	Random Horizontal Error Per Point (σ_H – meters)	Relative Horizontal Accuracy Between Points (R_h – meters)	Goal: Absolute Horizontal Accuracy CE90 (meters)
HRE80	8	2.83	8.00	10.00
HRE40	4	1.41	4.00	5.00
HRE20	2	0.71	2.00	3.00
HRE10	1	0.35	1.00	2.00
HRE05	0.50	0.18	0.50	1.00
HRE02	0.25	0.09	0.25	0.50*
HRE01	0.125	0.04	0.125	0.25*

Horizontal Accuracy notes:

1. The random horizontal error is the random circular error at point (reported at 90% confidence)
2. The Relative Horizontal Accuracy (point-to-point) between points is calculated at the 90% confidence interval.
3. The relative (point-to-point) horizontal accuracy is based on a distance (“D”) which is determined by the size of a standard HRE dataset at a given HRE Level. “D” is defined as the maximum radial distance between any two points in the said tile. The relative error is expected to vary as a function of distance between points, and its

value ranges from R_0 for points within one point spacing to the table value for points at distance "D".

4. The absolute horizontal accuracy is a goal value, but not a requirement. Although not required to meet a threshold, the Absolute Horizontal Accuracy should be reported in the metadata and is measured at the 90% confidence interval as a CE90.
5. Relative Horizontal Accuracy and random horizontal error may be difficult to assess in the coarse datasets. In these datasets, very large targets (which may not be available) would be required for such assessment. Therefore, the relative horizontal accuracy may not be evaluated for HREGP, HRE80 and HRE40 (Levels 1, 2, and 3).

*Note: These absolute horizontal accuracy values may be beyond current capabilities.

8.2. Vertical Accuracy:

HRE products at a given Level, shall conform with the predefined thresholds for vertical accuracy. Randomly selected datasets will be tested to assure that the random vertical error per point and relative vertical accuracy between points meets or exceeds the thresholds detailed in the tables below. Additionally, there is a goal that the absolute vertical accuracy meet or exceed the values established in Table 8-3 HREGP Vertical Accuracy Requirements and Table 8-4 HRE80-HRE01 Vertical Accuracy Requirements

Table 8-3 HREGP Vertical Accuracy Requirements

Product Name	Spatial resolution in arc seconds	Random Vertical Error Per Point (σ_V – meters)	Relative Vertical Accuracy Between Points (R_V – meters)	Goal: Absolute Vertical Accuracy LE90 (meters)
HREGP	0.4	2.2	6.2	12.4

Table 8-4 HRE80-HRE01 Vertical Accuracy Requirements

Product Name	Grid spatial resolution in meters	Random Vertical Error Per Point (σ_v – meters)	Relative Vertical Accuracy Between Points (R_v – meters)	Goal: Absolute Vertical Accuracy LE90 (meters)
HRE80	8	1.41	4.00	8.00
HRE40	4	0.71	2.00	4.00
HRE20	2	0.35	1.00	2.00
HRE10	1	0.18	0.50	1.00
HRE05	0.50	0.09	0.25	0.50
HRE02	0.25	0.04	0.12	0.25
HRE01	0.125	0.02	0.06	0.12

Vertical Accuracy notes:

1. The random vertical error per point is the random linear error per point (reported at 90% confidence)
2. The Relative Vertical Accuracy (point-to-point) between points is defined at the 90% confidence
3. The relative (point-to-point) vertical accuracy is based on a distance (“D”) which is determined by the size of a standard HRE tile at a given HRE Level. “D” is defined as the maximum radial distance between any two points in the said tile. The relative error is expected to vary as a function of distance between points, and its value ranges from R_0 for points within one point spacing to the table value for points at distance “D”.
4. The vertical accuracies described above are based on low to medium relief areas (predominant slope from 0 to 20 percent) within the data cell. In areas where the predominant slope exceeds 20 percent, the vertical accuracies listed in the table above can be scaled by 1.4 to account for increased inaccuracies.
5. The Absolute Vertical Accuracy is a goal value, but not a value that is required to meet a threshold in a HRE product. Although not required to meet a threshold, the Absolute Vertical Accuracy is measured at the 90% confidence interval as a LE90 and should be reported in the metadata.

9. Data Capture

HRE datasets are a derived dataset and may be generated from a variety of sources and production processes. Resolution and accuracy are critical criteria when deriving datasets. Where deemed necessary or appropriate, finer resolution elevation datasets may be used to derive coarser resolution elevation datasets, however coarser resolution datasets must not be used to derive finer resolution datasets. Equally only elevation datasets of higher accuracy shall be used to derive elevation datasets of lower accuracy. Specific HRE data capture requirements will be defined in product specific guidance documentation that will accompany production assignments. Typical guidance would include specific instruction for surface type depiction, water body portrayal, optional accuracy derivation (per point or regional) or other data portrayal requirements.

10. Data Maintenance

HRE datasets will be maintained and updated as requirements dictate. Data maintenance criteria will vary by data level. Higher resolution elevation data is more likely to need updates or replacement due to the temporal nature of high resolution details.

11. Data Product Delivery

HRE elevation layers will be stored and disseminated to NGA geospatial customers using NGA distribution capabilities and the NGA Product Gateway. Data delivery media and specific instruction will vary for the HRE data types. Specific instructions are documented in the product specific guidance for HRE products.

11.1. File Naming Convention

Finished HRE datasets that are prepared for distribution will follow the file naming convention as described below. Interim working products are not constrained by this convention. Also, data delivery media and specific instruction will vary for the HRE data types. Specific instructions are documented in the product specific guidance for HRE products. Table 11-1 File Name Extension defines the standard file naming convention.

Table 11-1 File Name Extension

Level	Product Name	File Name Extension
1	HREGP	.hr1
2	HRE80	.hr2
3	HRE40	.hr3
4	HRE20	.hr4
5	HRE10	.hr5
6	HRE05	.hr6
7	HRE02	.hr7
8	HRE01	.hr8

File Name:

HRE*rrtvvDDMMSShDDDMMSSe_cxx*.hr*f*
Where:

HRE = HRE is fixed
rr = resolution/projection (2 character alpha-numeric projection/post spacing)

- The rr value will use letters "GP" for Geographic Unprojected Position.
- The rr value will be the truncated decimeter value of the post spacing. This value will be from the enumerated list: 80, 40, 20, 10, 05, 02 or 01.

t = data type code (1 alpha-numeric character)
Code Key

A = optical source, unedited reflective surface
B = optical source, edited reflective surface
C = optical source, edited bare earth surface
D = Reserved for future use
E = Reserved for future use

F = IFSAR source, unedited reflective surface
G = IFSAR source, edited reflective surface
H = IFSAR source, edited bare earth surface
I = Reserved for future use
J = Reserved for future use

K = LIDAR source, unedited first return
L = LIDAR source, unedited last return
M= LIDAR source, unedited bare earth
N = LIDAR source, edited first return
O = LIDAR source, edited last return
P = LIDAR source, edited bare earth
Q = Reserved for future use
R = Reserved for future use
S = Reserved for future use
T = SAR source, unedited reflective surface
U = SAR source, edited reflective surface
V = SAR source, edited bare earth
W = Reserved for future use
X = unidentified source, reflective surface
Y = unidentified source, bare earth surface
Z = Reserved for future use

vv = file version number

DDMMSS = SW corner of DEM (Degree, Minute, Second)
h = hemisphere (N for North, S for South)
DDDMMSS = SW corner of DEM (Degree, Minute, Second)
e = hemisphere (E for East, W for West)
c = security classification (T, S, C, R, U)
xx = Release Code (2 character code equal to the value of the FSCTLH field in Table A-1)
hr = hr is fixed
f = level code (see Table 11.1)

12. HRE Product Files

The HRE Product files shall consist of a number of standardized components. Some HRE components are required, while other components are optional depending on mission requirements. The required components, as shown in Table 12-1, are those directly associated with expressing the elevation matrix data and associated metadata in an NITF 2.1 file. The optional HRE components include Shapefile data, and NITF segments and XML metadata modules supporting error propagation.

12.1. HRE NITF files

NITF Headers and Extensions are detailed in Annex A.

Each HRE NITF file shall contain:

- File Header
- Extended Header Data to include the PIAPRD Tagged Record Extension (TRE)
- Image Subheader for DEM Height Data
- DEM Height Data
- XML Metadata Data Extension Segment (Annexes A and B)

- Accuracy summary statistics (Annex B)
- Optional error propagation data (Annexes A, B, C)

Table 12-1 HRE File Components Requirements

HRE Component	**NITF Header**	**Image Segment Sub header & Data**	**XML DES**	**Shapefile DES**	**Comments**
File Header	Required				{1}
PIAPRD TRE	Required				{1}
Elevation Data		Required			{1}
Error Data		Optional			
XML Metadata			Required		{1}
Accuracy Summary Statistics			Required		{4 to 12}
Shapefile Data				Optional	{Multiple sets may be included.}
Error Propagation Data to be included in XML DES metadata (Optional, but recommended)					
Region Definition by Polygons – Method 1			{1 to N}		Two alternate methods are provided to define regions. They are mutually exclusive.
Region Definition per Post – Method 2		{1}	{1} *		
Accuracy Summary Statistics per Region			{(4 to 12)N}		Summary statistics may optionally be defined for each region.
Systematic Error per Region			{1 to N}		Always included
Cross Region Systematic Error			{N/2 (N-1)}		Included for 2 or more regions.
Relative Error Covariance by Region			{2 to 2N}		Always included. Relative error requires 2 covariance matrices per region (U and V directions)
Random Error Covariance – Method 1					Two alternate methods are provided to define random error covariance terms. They are mutually exclusive.
Random Error Covariance per Region			{1 to N}		
Random Error Scale Factor per Post		{1}	{1} *		
Random Error Covariance – Method 2					
Random Error Variance Terms per Post		{1}	{1} *		
Random Error Cross Correlation Terms per Post		{1}	{1} *		

* Error components stored in NITF image segments are always also referenced in the XML metadata.
NOTE: Item in brackets refers to number of instances in the file. "N" refers to the number of the regions defined.

Optionally the NITF file may contain Error data associated with the elevation data. These include Error propagation region point-by-point values, Error propagation random error point-by-point scale factor values, Error propagation random error point-by-point covariance values, and Error propagation random error point-by-point correlation coefficient values. For each of these data types the NITF file will contain:

- Image Subheader for Error Data type
- Error Data

One image segment containing the elevation data is always present in an HRE NITF file. When error propagation metadata is included, the NITF file may contain 1, 2 or 3 additional image segments. One of these image segments may contain region definitions per post, dependent on the method used to define the regions. Additionally, when error propagation data is included, image segments (one or two) will be used to capture the random error per post. If the scale factor method is used for the random errors, this will consist of one image segment. Alternatively, the random errors could be expressed with one image segment for random error variance terms and a second segment for the cross-correlation terms. So, a complete HRE NITF file will contain from one to four image segments.

The detailed specifics of the encapsulation of this Error data into NITF are referenced in Annex A.

When possible, systems (i.e. mission planners, targeting systems, etc.) using this data should make use of the errors / uncertainty, to provide some estimation of the risk. In addition, this information could be used for weighting, when combining multiple datasets in one area.

In addition to the above NITF structures the following inclusions into the dataset are dependent on product specific guidance:

- Shapefile Data Extension Segments (Annex A)

Multiple types of ancillary shapefile data may be included in the HRE NITF datasets. Specific content and structure will be defined in the unique product specific guidance documentation. Shapefiles would typically be used to delineate water bodies, void areas, alternate source fill, or known anomalous data.

12.2. Data Compression

Compression of HRE datasets may be desirable; however current compression capabilities typically do not work well on raster elevation data sets. Consequently compression is currently not implemented for HRE data. Data compression may be adopted when suitable compression techniques are developed. The allowed codes for the NITF Image Segment Subheader Image Compression (IC) field are NC and NM. Use the code NM when a pad pixel mask table is included following the Image Segment Subheader. If no compression is applied use code NC.

12.3. File Size Estimates

HRE datasets have a recommended maximum elevation data size of 200 Mega bytes (MB). This size is recommended with the intent to limit network resources needed for electronic distribution. Table 12.2 Elevation Data File Size Estimates displays approximate limits for square shaped matrices (rows and columns with same counts). The elevation data size shall be reported in the NITF File header field LI001 and the row and column counts are reported in NROWS and NCOLS fields in the Image Subheader. The HRE NITF files themselves may be larger than these elevation data estimates when accompanied by a full set of Error data, shapefiles and metadata.

Table 12-2 Elevation Data File Size Estimates

	GSD	**Rows/Columns**	**Area (sq km)**	**Size (MB)**
HREGP	12	10200	14981	198.44
HRE80	8	7200	3317	197.75
HRE40	4	7200	829	197.75
HRE20	2	7200	207	197.75
HRE10	1	7200	51	197.75
HRE05	0.5	7200	12	197.75
HRE02	0.25	7200	3	197.75
HRE01	0.125	7200	1	197.75

12.4. Tiling

This HRE Profile does not require a specific collection tiling scheme for HRE products. Collection tiling is described in the International Elevation Surface Model (ESM) standard. A collection tiling scheme is one that is defined after the datasets are encoded into format files (e.g. NITF for HRE). Collection tiling is not to be confused with ‘format’ tiling (i.e. blocking) within the NITF file.

In the metadata associated with each HRE NITF file in a tiled collection, identification of the tile that contains the HRE NITF file is required (see Table B.1). A separate metadata set is required for description of the tiled collection. The collection metadata will include an additional element that references the tiling scheme documentation where the tile dimensions and identification mechanism are described.

13. Security

HRE data shall comply with all DOD data security classifications and markings directives as specified in US Code Title 50, the National Security Act of 1947, NSG Directive FM1100, and Executive Order 12958.

Individual HRE data and supporting files may have different security classifications and markings but when provided as one dataset or combined, the results shall be marked with the highest security level of the individual datasets.

14. Metadata

14.1. General

Details for metadata content are found in Annex B Metadata Specification

Metadata may be associated with elevation data in several ways:

- with an elevation collection or series;
- with a single fundamental elevation dataset;
- with particular regions of a dataset or with some other grouping of dataset elements;
- with individual elevation points.

The description of metadata is hierarchical, so that any metadata element at a higher association level applies unless superseded by more detailed metadata at a lower association level.

14.2. Metadata uses

Among the fundamental purposes for compiling and maintain metadata, two are of particular relevance for this profile. They are:

- To assist users in discovering and obtaining elevation data sets that may be capable of supporting their applications for elevation data;
- To assist users in exploiting elevation data sets once obtained.

14.3. Metadata Data Types

Listed below are the metadata data type definitions.

Boolean

truth Enumeration whose domain of values is { TRUE, FALSE }, representing the true and false values in a two-valued logic system

CharacterString

character string with optional character encoding and localization attributes

Codelist

value domain including a code for each permissible value

NOTE It is an open Enumeration that may be extended during system runtime by adding additional named literal values.

Date

indication of date expressed as a year, year-month, or year-month-day

NOTE As specified by ISO 8601.

DateTime

indication of time expressed as a year, year-month, year-month-day, or year-month-day and time of day

NOTE As specified by ISO 8601.

Enumeration

data type whose instances form a finite list of distinguished values

NOTE 1 The extension of an Enumeration type implies a schema modification.

NOTE 2 An Enumeration should be used only when it is clear that there will be no extensions, otherwise a Codelist should be used.

Integer

whole number (a number that does not have a fractional part)

Real

number that is either rational or irrational

URI

CharacterString containing a Uniform Resource Identifier corresponding to the World Wide Web Consortium (W3C) recommendation

URL

CharacterString containing a Uniform Resource Locator corresponding to the W3C recommendation

14.4. Metadata modules

Elevation Data Accuracy Summary Statistics for HRE Products

This section describes the minimum accuracy related metadata elements to be reported for every HRE Standard dataset.

The HRE NITF file will contain XML metadata in a DQ_DataQuality module for the following values and the data vendor is required to provide the following values and store them in the HRE Standard product metadata for all HRE standard products (HREGP and HRE80 thru HRE01):

- Predicted / vendor measured Absolute Horizontal Accuracy ($CE90_{ABS,Pre}$)
- Predicted / vendor measured Absolute Vertical Accuracy ($LE90_{ABS,Pre}$)
- Predicted / vendor measured Relative Vertical Accuracy ($LE90_{REL,Pre}$)
- Predicted / vendor measured Random Vertical Error ($\sigma_{V,Pre}$)

Please note that these required reported values are to be representative of the entire dataset and not relate to a specific sub-cell, sub-section, or region. However, the file format does support the storage of these values on a per region basis when this information is available.

For HRE20 thru HRE01, the following values (in addition to the above values) are also required to be provided by the data vendor in the HRE Standard product metadata and stored in a DQ_DataQuality module:

- Predicted / vendor measured Random Horizontal Error ($\sigma_{H,Pre}$)
- Predicted / vendor measured Relative Horizontal Accuracy ($CE90_{REL,Pre}$)

Although random horizontal and relative horizontal values are not required for HREGP and HRE80-40, they can (and should) be reported if they were measured or if representative predictive values are available.

The HRE NITF file XML metadata will contain additional record sets of DQ_DataQuality modules that apply to the entire DEM if the dataset has been tested (by NGA or others) for validation. When tested, the following fields will be populated for all HRE standard products (HREGP and HRE80 thru HRE01):

- NGA measured / validated Absolute Horizontal Accuracy ($CE90_{ABS,Val}$)
- NGA measured / validated Absolute Vertical Accuracy ($LE90_{ABS,Val}$)
- NGA measured / validated Relative Vertical Accuracy ($LE90_{REL,Val}$)
- NGA measured / validated Random Vertical Error ($\sigma_{V,Val}$)

NOTE: If similar values have been created on a per region level, these can be reported and stored in the metadata. However, these values are not required by the Implementation Profile for High Resolution Elevation (HRE) Products.

The goal of this section is to provide the team testing the data (NGA or others) a place to report summary results of their evaluation of the dataset. These fields will provide the user with the information required to determine if a dataset (or region in some cases) accuracy can support certain critical applications. The absence of these fields would indicate to the user that the dataset was not tested against ground truth.

When HRE20 thru HRE01 are evaluated, the following values (in addition to the above values) will also be recorded in the metadata:

- NGA measured / validated Random Horizontal Error ($\sigma_{H,Val}$)
- NGA measured / validated Relative Horizontal Accuracy ($CE90_{REL,Val}$)

If possible, these values should be provided when assessing HREGP and HRE80-40. However, this will not always be possible.

Table 14-1 HRE Accuracy Metadata Reporting Requirements and Table 14-2 HRE Accuracy Metadata Reporting Requirements if dataset accuracy is tested summarize these reporting requirements:

Table 14-1 HRE Accuracy Metadata Reporting Requirements

Source	Accuracy Value	Required for all HRE Datasets, HREGP and HRE80 thru HRE01	Required for HRE20 thru HRE01 and reported for all HRE levels if measured or predicted by vendor
Vendor Provided	Predicted / vendor measured Absolute Horizontal Accuracy ($CE90_{ABS,Pre}$)	✓	✓
	Predicted / vendor measured Absolute Vertical Accuracy ($LE90_{ABS,Pre}$)	✓	✓
	Predicted / vendor measured Relative Vertical Accuracy ($LE90_{REL,Pre}$)	✓	✓
	Predicted / vendor measured Random Horizontal Error Per Point ($\sigma_{H,Pre}$)		✓
	Predicted / vendor measured Relative Horizontal Accuracy ($CE90_{REL,Pre}$)		✓
	Predicted / vendor measured Random Vertical Error ($\sigma_{V,Pre}$)	✓	✓

Table 14-2 HRE Accuracy Metadata Reporting Requirements if dataset accuracy is tested

Source	Accuracy Value	Required for all HRE Datasets, HREGP and HRE80 thru HRE01, if dataset tested by NGA	Required for HRE 20-01 if dataset tested by NGA and reported for all HRE levels if measured
NGA Provided	NGA measured / validated Absolute Horizontal Accuracy ($CE90_{ABS,Val}$)	✓	✓
	NGA measured / validated Absolute Vertical Accuracy ($LE90_{ABS,Val}$)	✓	✓
	NGA measured / validated Relative Vertical Accuracy ($LE90_{REL,Val}$)	✓	✓
	NGA measured / validated Random Horizontal Error ($\sigma_{H,Val}$)		✓
	NGA measured / validated Relative Horizontal Accuracy ($CE90_{REL,Val}$)		✓
	NGA measured / validated Random Vertical Error ($\sigma_{V,Val}$)	✓	✓

Per Point Error Estimate

The use of high resolution elevation data for tasks that require a specified level of geolocation accuracy necessitates the inclusion of data to estimate geolocation errors anywhere within the elevation data coverage area. To support this need, this document proposes a new error metadata storage scheme within the NITF file using a series of DQ_DataQuality modules in conjunction with a series of NITF image segments. This error storage scheme provides the uncertainty data needed to compute estimated horizontal and vertical errors (both absolute and relative) for each point in the associated high resolution elevation image segment. This is accomplished by defining the fields needed to specify the covariance data for an accompanying data set. Standard error propagation techniques (i.e., linear combinations of Gaussian random variables) may then be used to compute a unique 3 by 3 covariance matrix for each point in the data set.

The metadata required to generate the per point error estimates consists of several sections. First, it consists of the definition of regions within which, uniform systematic errors are expected. Second, the information required to develop a 3x3 covariance matrix for the systematic errors within a region is stored along with the information necessary to develop the cross correlation between regions. Finally, the metadata required to build the 3x3 covariance matrix of random errors per point is stored. These individual pieces are then combined and exploited to determine the predicted errors at a single point or between a series of points.

This predicted error metadata is not required for HRE datasets. However, as mentioned above, as the exploitation capabilities on HRE datasets continue to expand, the necessity for such error prediction capabilities increases. For detailed guidance on the storage and exploitation, refer to Annex C (HRE Metadata in Support of Error Propagation).

ANNEX A – HRE NITF File Format (Normative)

A.1 Introduction

A.1.1 Overview

This annex specifies the requirements for formatting High Resolution Elevation Data (HRE) within a National Imagery Transmission Format (NITF) file. This includes the NITF File Header format, the NITF Image Segment format for containing HRE elevation data and related error propagation data, and the NITF Data Extension Segment (DES) format for metadata describing the HRE dataset. (See Figure A-1).

A.1.2 Metadata Overview

Metadata embedded within the HRE NITF file provides information about the organization, content, and structure of the NITF file, and information about the elevation data, to include data about the sensor that captured the elevations, support information about the elevations, and a host of other values. The main purpose of this annex is to describe the NITF file formatting required for specifying High Resolution Elevation Data (HRE). This includes specifying NITF header, sub-header, and Data Extension Segment (DES) field values, and the elevation data, error propagation data, and metadata (XML-formatted) contained within the NITF file structure. For convenience, this document contains excerpts and tables from standards documents (MIL-STD-2500C for example) so that referencing these documents can be kept to a minimum. For implementation of this profile, all documentation should be reviewed for accuracies before proceeding.

A.1.3 Coordinate System

A.1.3.1 Ground Space

Ground space coordinates expressed in the NITF Image Segments and Data Extension Segments are referenced to the World Geodetic System 1984 (WGS-84) coordinate system. Per the HRE specification, the coordinate references are expressed in decimal degrees as a bounding 4-point polygon. However, the Image Geographic Location field (IGEOLO) in the NITF image subheader indicates only the approximate geographic location of the image to only 3 decimal places, and is not intended for analytical purposes and only intended to support general user appreciation for the image location for such things as file cataloguing and discovery as used in libraries and repositories not capable of reading metadata store in the Data Extension Segment. For more precise understanding of the image location for use for analytical purposes the user should use the associated image location information maintained within the Data Extension Segment as the ground space coordinates and coordinate reference system for the actual elevation postings is identified in the XML_DATA_CONTENT DES using the metadata as specified in Table A-9 XML_Data_Content DES Subheader or in section Annex B. Note: the reliability of the IGEOLO becomes less effect the more accurate the HRE product, because of the lack of precision allowed in the IGEOLO field.

A.1.3.2 Image Space

Image (elevation post) space coordinates are defined in the NITF row and column coordinates indexing system. When the row/column coordinate system is positioned such that the origin (0,0) of the array is at the upper left, the integer or integral image space coordinates associated with a single cell are assigned to the upper left corner of the cell. The corresponding geospatial coordinates are associated with the center of the cell (e.g. cell index 0.5,0.5 for the origin cell) , for the purposes of this specification. This reflects the value is point case (vice the value is area case) applicable to elevation postings. Note, for general NITFS the IGEOLO location point of the geographic information is not directed in the standards. Hence, some applications could interpret the values stored in the IGEOLO to a point on the pixel other than the center point and adding to inaccuracies for the image location when using IGEOLO data.

A.2 Terms and Definitions

A.2.1 NITF References

NITF field format definitions were extracted from the NITF Version 2.1 (MIL-STD-2500C 1 May 2006). The Compendium of Controlled Extensions for the National Imagery Transmission Format Volume 1 (STDI-0002-1) Tagged Record Extensions defines the PIAPRD Tagged Record Extension (TRE) used with HRE data. Volume 2 (STDI-0002-2) Data Extension Segments defines both the XML_DATA_CONTENT Data Extension Segment (DES) and the CSSHPA Data Extension Segment (DES) optionally used with HRE data.

A.2.2 Field Format Definitions

Basic Character Set (BCS) –
A subset of the Extended Character Set (ECS). The most significant bit of the BCS character is set to 0. The range of valid BCS characters code is limited to 0x20 to 0x7E plus line feed (0x0A), form feed (0x0C), and carriage return (0x0D).

Basic Character Set-Alphanumeric (BCS-A) –
A subset of the Basic Character Set. The range of allowable characters consists of space through tilde (codes 0x20 through 0x7E); and line feed, form feed, and carriage return (0x0A, 0x0C, and 0x0D).

Basic Character Set-Numeric (BCS-N) –
A subset of the Basic Character Set-Alphanumeric. The range of allowable characters consists of minus through the number “9”, BCS codes 0x2D through 0x39, and plus, code 0x2B.

BCS Space –
BCS code 0x20.

Extended Character Set (ECS) –
A set of 1-byte encoded characters. Valid ECS character codes range from 0x20 to 0x7E, and 0xA0 to 0xFF, as well as Line Feed (0x0A), Form Feed (0x0C) and Carriage Return (0x0D). The ECS characters are described in Table B-1. As an interim measure, because of inconsistencies between standards, it is strongly advised that character codes ranging from 0xA0 to 0xFF should never be used. Therefore, the use of ECS characters should be restricted to its BCS Subset.

Field structure and default values. The NITF uses byte counts to delimit header fields, as opposed to special end-of-field characters or codes or direct addressing. These counts are provided in the tables detailing the NITF header and subheader field specifications. All data in fields designated “BCS-A” shall be left justified and padded to the right boundary with BCS spaces. All data in numeric fields (BCS-Numeric (BCS-N)) shall be right justified and padded to the left boundary with leading zeros. Where a BCS-N field allows a plus sign (code 0x2B) or a minus sign (code 0x2D), it is the left most character of the integer value. The standard default value shall be spaces for alphanumeric fields and zero for numeric fields. For a few fields, a specific default may be indicated in the field description. In this case, the field description shall take precedence. All header and subheader fields contained in a NITF file shall contain either meaningful data (that is, data in accordance with the restrictions specified for the contents of the field in this document) or the specified default value.

A.2.3 Field Type Definitions

Required (R)
Designates a NITF header or subheader field that must be present and filled with valid data.

Conditional (C)
A state applied to a NITF header or subheader data field whose existence and content is dependent on the existence and/or content of another field.

<R> or <C>
BCS Spaces allowed for entire field when no specific default value is specified.

[PSG]

PSG designates a NITF header or subheader field for which ‘production-specific guidance’ for population of the field will be provided by the HRE production sponsoring activity.

A.3 High Resolution Elevation Product Format

A.3.1 High Resolution Elevation Product Format Overview

High Resolution Elevation data is a product consisting of elevation data and associated metadata.

A.3.2 HRE NITF File Contents

The following diagram (Figure A-1) provides an overview of the NITF structure of an HRE product in block format. Subsequent sections provide further clarification of the format including NITF TRE(s).

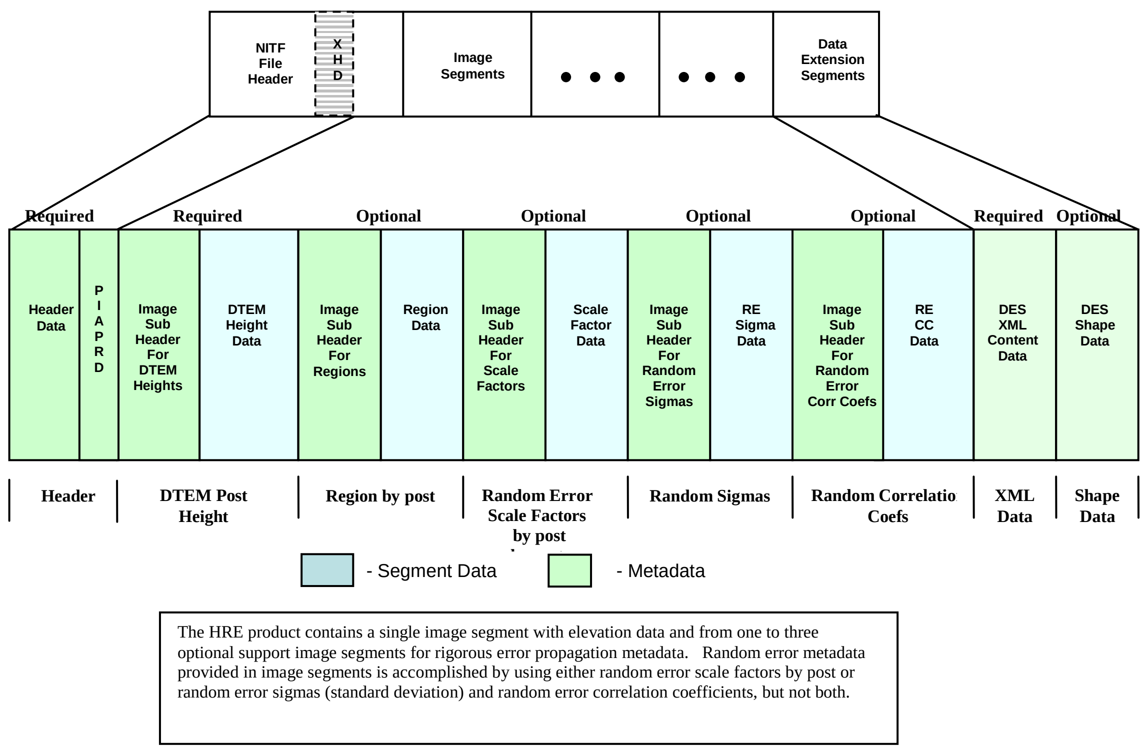
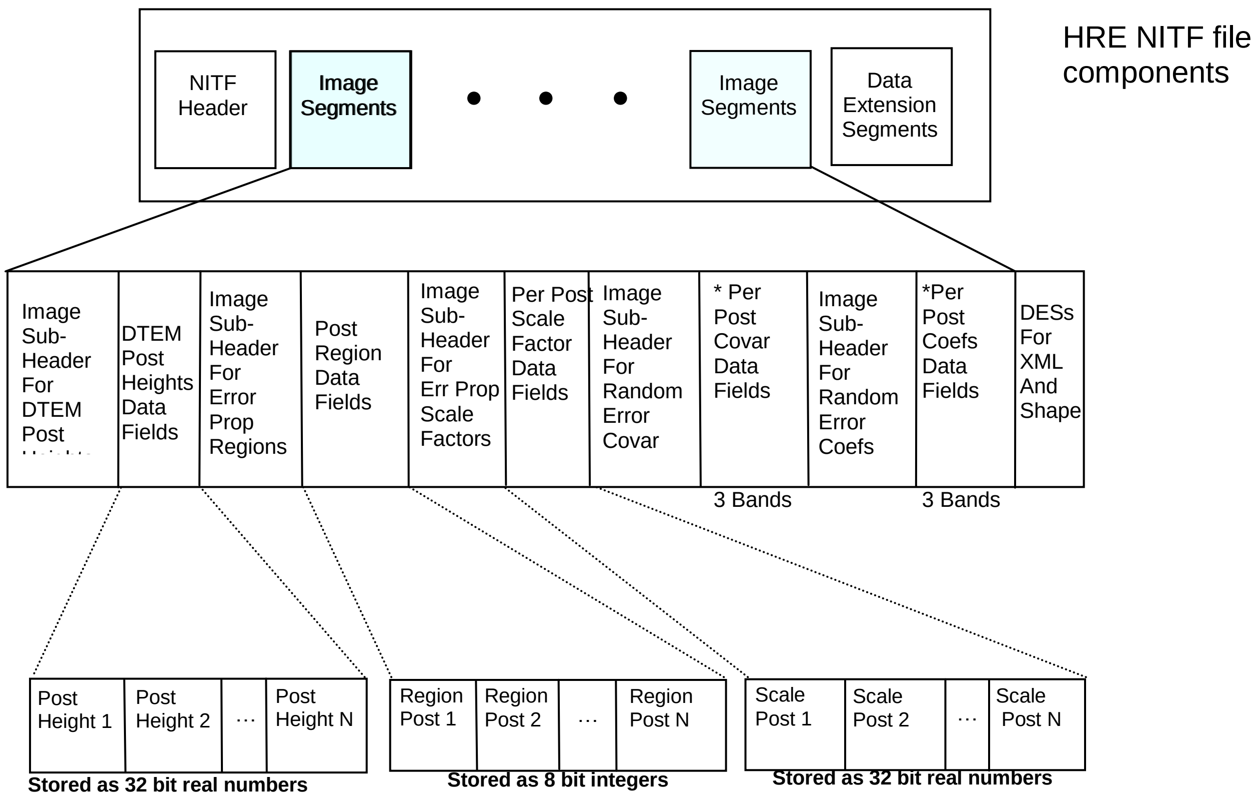


Figure A-1 Diagram showing NITF HRE File Format

A.3.3 TEM Post Height and Optional Error Propagation Image Segment Layout

Figure A.2 describes the storage layout of the DTEM Post Heights and optional rigorous error propagation image segments associated with DTEM posts (See Tables A-5 to A-8, Annex B.2, and Annex C). These values (when present) will be stored as separate image segments (DTEM Post Heights, Error propagation region post-by-post values, Error propagation random error post-by-post scale factor values, Error propagation random error post-by-post covariance values, and Error propagation random error post-by-post correlation coefficient values). Additional required metadata is supplied in the NITF XML_DATA_CONTENT DES.



NOTE: Asterisk (*) indicates the additional optional two image segments needed to specify the post-by-post random error covariance matrix elements. These are each 3-band image segments. One image segment consists of the three diagonal term standard deviations, stored as 4-byte real numbers So, a given band within a segment contains values representing a specific location within the covariance matrix, for example the σ_x location. The other two bands permit storage for σ_y and σ_z. The second image segment of the set consists of the three off-diagonal correlation coefficients, stored as 1-byte integers. A given band then represents a specific off-diagonal term, σ_{xy}, σ_{xz}, or σ_{yz}.

Figure A-2 Diagram indicating potential image segment components for the HRE product

A.4 NITF File Header Layout

A.4.1 Header Format

Table A-1 shows how the NITF File Header shall be populated during the creation of the HRE product. The table provides details for populating header fields and places HRE-specific constraints for use of NITF (e.g. tighter value range constraints and obligations than allowed in the NITF standard). In some instances, the desired field value is not known until a data production order or plan is in place. Those fields for which Production Specific Guidance (PSG) is anticipated are designated with the letters 'PSG'.

Table A-1 NITF File Header Format for NITF 2.10 images

(Type "R"=Required, "C" = Conditional, "<>" BCS Spaces allowed for entire field)

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
FHDR	<u>File Profile Name</u> The valid value for this field is NITF.	4	BCS-A NITF	R	*Data written in NITF format.*
FVER	<u>File Version</u> The valid value for this field is 02.10.	5	BCS-A 02.10	R	*Data written in NITF version 02.10 format.*
CLEVEL	<u>Complexity Level</u> The complexity level required to interpret fully all components of the file.	2	BCS-A 03 to 09	R	*Primarily related to the number of DTEM posts. This is based on a value derived from* Table A-11.
STYPE	<u>Standard Type</u> Standard type or capability. BF01 indicates that this file is formatted using ISO/IEC IS 12087-5.	4	ECS-A BF01	R	*NITF version 02.10 is intended to be registered as a profile of ISO/IEC 12087-5.*
OSTAID	<u>Originating Station ID</u> Identification code or name of the originating organization, system, station, or product.	10	ECS-A	R	*Organization responsible for producing the final data file.*
FDT	<u>File Date & Time</u> The date and time (UTC) of the file's origination.	14	BCS-N *CCYYMMDDhhmmss*	R	*Date and time of the creation of the HRE file.* *Format*: *CCYYMMDDhhmmss*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
FTITLE	File Title This field contains the title of the file.	80	ECS-A *HRE High Resolution Elevation Data HRErrtvvDDMMSShDDDMMSSe_cxx.hrf*	R [PSG]	*"HRE High Resolution Elevation Data HRErrtvvDDMMSShDDD MMSSe_cxx.hrf "* *This is the file name as defined in Section 11.1.*
FSCLAS	File Security Classification This value contains a valid value representing the classification level of the entire file.	1	ECS-A T, S, C, R, or U	R [PSG]	*For fields FSCLAS through FSCTLN, consult Production Specific Guidance (PSG) for applicable security field population values.*
FSCLSY	File Security Classification System This field shall contain valid values indicating the national or multinational security system used to classify the file.	2	ECS-A US Note: this field may contain two space characters when the FSCLAS value is 'U'.	<R> [PSG]	*Refer to MIL-STD-2500C for general description of these fields. Consult current security guidelines at the time of production to determine proper markings.*
FSCODE	File Codewords This field shall contain a valid indicator of the security compartments associated with the file	11	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSCTLH	File Control and Handling This field shall contain valid additional security control and/or handling instructions (caveats) associated with the file.	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSREL	File Releasing Instructions This field shall contain a valid list of country and/or multilateral entity codes to which countries and/or multilateral entities the file is authorized for release.	20	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
FSDCTP	File Declassification Type This field shall contain a valid indicator of the type of security declassification or downgrading instructions which apply to the file.	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSDCDT	File Declassification Date This field shall contain a date on which a file is to be declassified if the value in the File Declassification Type is DD, DE, GD, GE, O, and X.	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSDCXM	File Declassification Exemption This field shall indicate the reason the file is exempt from automatic declassification if the value in File Declassification Type is X.	4	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSDG	File Downgrade This field shall contain the classification level to which a file is to be downgraded if the value in the File Declassification Type is GD or GE.	1	ECS-A S, C, R	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSDGDT	File Downgrade Date This field shall indicate the date on which a file is to be downgraded if the File Declassification Type is GD.	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
FSCLTX	File Classification Text This field shall be used to provide additional information about file classification to include identification of a declassification or downgrading event if the values in the File Declassification Type are DE or GE.	43	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSCATP	File Classification Authority Type This field shall indicate the type of authority used to classify the file.	1	ECS-A O, D, M	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSCAUT	File Classification Authority This field shall identify the classification authority for the file dependent upon the value in File Classification Authority Type.	40	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSCRSN	File Classification Reason This field shall contain values indicating the reason for classifying the file.	1	ECS-A A through G.	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSSRDT	File Security Source Date This field shall indicate the date of the source used to derive the classification of the file.	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
FSCTLN	File Security Control Number This field shall contain a valid security control number associated with the file.	15	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
FSCOP	File Copy Number This field shall contain the copy number of the file.	5	BCS-N 00000	R	*If the field is all zeros, this shall imply that there is no tracking of the number of copies.*
FSCPYS	File Number of Copies This field shall contain the total number of copies of the file.	5	BCS-N 00000	R	*If the field is all zeros, this shall imply that there is no tracking of the number of copies.*
ENCRYP	Encryption This field shall contain the value BCS zero (0x30).	1	BCS-N 0	R	Default 0 = Not Encrypted
FBKGC	File Background Color This field shall contain the three color components of the file background in the order Red, Green, Blue.	3	Unsigned Binary Integer *0x00, 0x00, and 0x00*	R	*This field contains unsigned binary integer values with a range of 0x00, 0x00, and 0x00 (Black) to 0xFF, 0xFF, 0xFF (White).*
ONAME	Originator's Name This field shall contain a valid name for the operator who originated the file.	24	ECS-A	R [PSG]	*Lists the organization responsible for creating the final data product and shall be followed by BCS spaces to reach size.*
OPHONE	Originator's Phone Number This field shall contain a valid phone number for the operator who originated the file.	18	ECS-A	R [PSG]	*Originator's phone number followed by BCS spaces to fill size.*
FL	File Length This field shall contain the length in bytes of the entire file including all headers, subheaders, and data.	12	BCS-N 000000000388 to 999999999998	R	*BCS-N positive integer Calculated length of entire file in bytes, including all headers, subheaders and data.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
HL	NITF File Header Length This field shall contain a valid length in bytes of the NITF file header.	6	BCS-N 000388 to 999998	R	*BCS-N positive integer. Length of NITF file header in bytes*
NUMI	Number of Image Segments Indicates the number of image segments in the NITF file.	3	BCS-N 001 to 004	R	*Reference Table 12-1.*
LISH001	Length of 1st Image Subheader This field shall contain a valid length in bytes for the image subheader.	6	BCS-N 000439 to 999998	R	*Length of the DTEM Post Height image subheader*
LI001	Length of 1st Image This field shall contain a valid length in bytes of the image data.	10	BCS-N 0000000001 to 9999999998	R	*Length of the DTEM Post Heights image segment*
LISHn	Length of nth Image Subheader	6	BCS-N 000439 to 999998	C	*Length of the Rigorous Error Propagation Region Definition image subheader, if present.*
LIn	Length of nth Image	10	BCS-N 0000000001 to 9999999998	C	*Length of the Rigorous Error Propagation Region Definition image segment, if present.*
LISHn	Length of nth Image Subheader	6	BCS-N 000439 to 999998	C	*Length of the Rigorous Error Propagation Scale Factor Definition image subheader, if present.*
LIn	Length of nth Image	10	BCS-N 0000000001 to 9999999998	C	*Length of the Rigorous Error Propagation Scale Factor Definition image segment, if present.*
LISHn	Length of nth Image Subheader	6	BCS-N 000439 to 999998	C	*Length of the Rigorous Error Propagation Random Error Covariance Definition image subheader, if present.*
LIn	Length of nth Image	10	BCS-N 0000000001 to 9999999998	C	*Length of the Rigorous Error Propagation Random Error Covariance Definition image segment, if present.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
LISHn	Length of nth Image Subheader	6	BCS-N 000439 to 999998	C	*Length of the Rigorous Error Propagation Random Error Correlation Coefficient Definition image subheader, if present.*
LIn	Length of nth Image	10	BCS-N 0000000001 to 9999999998	C	*Length of the Rigorous Error Propagation Random Error Correlation Coefficient Definition image segment, if present.*
NUMS	Number of Graphics This field shall contain the number of separate graphic segments included in the file.	3	BCS-N 000-999 Default value is 000	R [PSG]	*This shall be"000" unless graphics are added. Inclusion of Graphics is optional.*
LSSHn	Length of nth Graphic Subheader This field shall contain a valid length in bytes for the nth graphic subheader, where n is the number of the graphic segment counting from the first graphic (n=001) in the order of the graphic segments' appearance in the file.	4	BCS-N 0258 to 9998	C	*Inclusion of Graphics is optional.*
LSn	Length of the nth Graphic This field shall contain a valid length in bytes of the nth graphic, where n is the number of the graphic segment counting from the first graphic (n=001) in the order of the graphic segments' appearance in the file.	6	BCS-N 000001 to 999998	C	*Inclusion of Graphics is optional.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
NUMX	Reserved for Future Use This field is reserved for future use.	3	BCS-N 000	R	*This field shall be filled with BCS zeros (0x30)*
NUMT	Number of Text Files This field shall contain the number of separate text segment(s) included in the file.	3	BCS-N 000-999 Default value is 000	R [PSG]	*This shall be "000" unless text segments are added. Inclusion of text segments is optional.*
LTSHn	Length of the n^{th} text subheader This field shall contain a valid length in bytes for the n^{th} text subheader, where n is the number of the text segment, counting from the first text segment (n=001) in the order of the text segments' appearance in the file.	4	BCS-N 0282 to 9998	C	*Inclusion of text segments is optional.*
LTn	Length of the n^{th} Text file This field shall contain a valid length in bytes of the n^{th} text segment, where n is the number of the text segment, counting from the first text segment (n=001) in the order of the text segments' appearances in the file.	5	BCS-N 00001 to 99998	C	*Inclusion of text segments is optional.*
NUMDES	Number of Data Extension Segments This field shall contain the number of separate data extension segments included in the file.	3	BCS-N 001 to 010	R [PSG]	*An HRE NITF file will always have at least one DES to contain XML-formatted metadata. The file may also include DES(s) with Shapefiles.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
LDSH001	Length of the 1st Data Extension Segment Subheader This field shall contain a valid length in bytes for the 1st data extension segment subheader.	4	BCS-N 0200 to 9998	R	*Length in bytes of the XML_DATA_CONTENT DES subheader.*
LD001	Length of 1st Data Extension Segment Data This field shall contain a valid length in bytes of the data in the 1th data extension segment.	9	BCS-N 000000001 to 999999998	R	*Length in bytes of the data in the XML_DATA_CONTENT DES.*
LDSHn	Length of the nth Data Extension Segment Subheader This field shall contain a valid length in bytes for the nth data extension segment subheader, where n is the number of the data extension segment *counting from the first data extension segment (n=001) in order of the data extension segment's appearance in the file.*	4	BCS-N 0200 to 9998	C	*Length in bytes of the CSSHPA DES subheader, if present.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
LDn	Length of n^{th} Data Extension Segment Data This field shall contain a valid length in bytes of the data in the n^{th} data extension segment, where n is the number of the data extension segment counting from the first data extension segment (n=001) in order of the data extension segment's appearance in the file.	9	BCS-N 000000001 to 999999998	C	*Length in bytes of the data in the CSSHPA DES, if present.*
NUMRES	Number of Reserved Extension Segments This field shall contain the number of separate reserved extension segments included in the file.	3	BCS-N 000	R	*"000" There are no reserved extension segments included in the file.*
UDHDL	User Defined Header Data Length A value of BCS zeros shall represent that no tagged record extensions are included in the UDHD.	5	BCS-N 00000	R	*There are no TREs included in the User Defined Header.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
XHDL	<u>Extended Header Data Length</u> This field shall contain a valid length in bytes for all the TREs in the extended header data portion of NITF file. The field shall contain the sum of the length of all the tagged record extensions appearing in the XHD field plus 3 bytes (length of XHDLOFL).	5	BCS-N	R	*The only TRE to appear in the Extended Header Data is the PIAPRD TRE.*
XHDLOFL	<u>Extended Header Data Overflow</u> This field shall contain BCS zeros (0x30) if the tagged record extensions in XHD do not overflow into a DES, or shall contain the sequence number of the DES into which they do overflow.	3	BCS-N 000	C	*A TRE overflow condition does not exist for HRE data.*
XHD	<u>Extended Header Data</u> This field shall contain controlled tagged record extensions. The length of this field shall be the length specified by the field XHDL minus 3 bytes. Controlled tagged record extensions shall appear one after the other with no intervening bytes.	†[1]	PIAPRD TRE	C	*The PIAPRD TRE is placed in this field.*

†[1] - As Specified in XHDL minus 3 bytes

A.4.2 Extended Header Data

A.4.3 PIAPRD TRE Format

Profile for Imagery Access Product Support Extension TRE

Support information about HRE product processing including date/time, software type, and software version will be stored in the PIAPRD TRE. In addition, this TRE will hold information about additional image sections within the product. These sections include unique identifiers (IDs) for the HRE DTEM Post Height segment, and if present, Rigorous Error Propagation Region definition, Rigorous Error Propagation random error Scale Factor definition, Rigorous error Propagation random error Covariance data, and Rigorous Error Propagation random error Correlation Coefficient data image segments. These IDs are used to associate the HRE DTEM Post Heights, with any of the Rigorous Error Propagation image segments that may be included.

Table A-2 PIAPRD TRE Format

(Type "R"=Required, "C" = Conditional, "<>" = BCS Spaces Allowed for Entire Field)

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
CETAG	Unique Extension Identifier	6	BCS-A PIAPRD	R	
CEL	Length of Entire Tagged Record	5	BCS-N 00201-63759	R	
ACCESSID	Access ID	64	BCS-A	<R>	*Default – BCS Spaces*
FMCONTROL	FM Control Number	32	BCS-A	<R>	*Default – BCS Spaces*
SUBDET	Subjective Detail	1	BCS-A	<R>	*Default – BCS Space* P - Poor, F - Fair, G - Good, E – Excellent
PRODCODE	Product Code	2	BCS-A	<R>	*Default – BCS Spaces*
PRODUCERSE	Producer Supplement	6	BCS-A	<R>	*Default – BCS Spaces*
PRODIDNO	Product ID Number	20	BCS-A	<R>	*Default – BCS Spaces*
PRODSNME	Product Short Name Identifies the abbreviated name of a product stored in the archive.	10	BCS-A *HRE*	R	*"HRE"*
PRODUCERCD	Producer Code	2	BCS-A	<R>	*Default – BCS Spaces*
PRODCERTIME	Producer Time Identifies the date or the date and time that the product was created or last modified, expressed in ZULU time.	14	BCS-A CCYYMMDDHHMMSS (ZULU)	R	Date or date and time of the version number reported in the file title (FTITLE) field in the file header
MAPID	Map ID	40	BCS-A	<R>	*Default – BCS Spaces*
SECTITLEREP	SECTITLE Repetitions	2	BCS-N 00	R	*"00" – Indicating zero repeating SECTITLE values*

REQORGREP	REQORG Repetitions	2	BCS-N 00	R	*"00" – Indicating zero repeating REQORG values*
KEYWORDREP	KEYWORD Repetitions	2	BCS-N 00	R	*"00" No keywords are used.*
ASSRPTREP	ASSPRT Repetitions	2	BCS-N 00	R	*"00" – Indicating zero repeating ASSRPT values*
ATEXTREP	ATEXT Repetitions Identifies the number of times the ATEXTREP field repeats per extension instance.	2	BCS-N 01 - 05	R	*For HRE, this is the number of Image Segments contained within the HRE (Typically 01 to 05). This number is used to determine how many ATEXT fields will follow. These ATEXT fields represent unique Segment IDs contained in the IID2 (NITF 2.10) fields of the image segments.*
ATEXTnn	Associated Text nn Provides the nnth text block further describing the imagery product. The number of ATEXTs between the previous field and this is represented in the ATEXTREP field.	255	BCS-A *HRELLyyyymmdd*	C	*This is used as an internal HRE identification number mechanism.* *The format for the DTEM Post Heights, identification tags is:* *HRELLyyyymmdd*
	Where: ○ *HRE – required portion of keyword for HRE DTEM segment* ○ *LL – the two character HRE product designator (e.g. HREGP, LL will be "GP").* ○ *yyyymmdd format, where yyyy is the year, mm is the month, and dd is the day of the month* *The format for any rigorous error image segments included will follow the same format pattern, with the first three letters changed to one of the following, identification tags:* ○ *REG – required portion of keyword for rigorous error regions segment* ○ *RSF – required portion of keyword for rigorous error random error scale factor segment* ○ *COV – required portion of keyword for rigorous error propagation random error covariance segment* ○ *COR – required portion of keyword for rigorous error propagation random error correlation coefficient segment* *NOTE:* *The exploitation system will be able to match these segments by comparing these values.*				

A.5 HRE Post Height

A.5.1 HRE Post Height

The first, and possibly only, image segment in the HRE NITF product contains the elevation data post heights. This image segment is comprised of Image subheader information and DTEM post height data. Metadata associated with the DTEM data is contained in the XML_DATA_CONTENT DES.

A.5.2 Image Subheader

This section describes the fields and contents within the IM subheader. For the DTEM Post Heights, this IM subheader will contain the values designated in Table A-3.

Table A-3 HRE Post Height Image Subheader Format

(Type "R"=Required, "C" = Conditional, "<>" BCS Spaces allowed for entire field)

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IM	File Part Type This field shall contain the characters "IM" to identify the subheader as an image subheader.	2	BCS-A IM	R	*"IM"*
IID1	Image ID1 This field shall contain a valid alphanumeric identification code associated with the image.	10	BCS-A HRE	R	*"HRE"* *Short name that identifies the DTEM Post Height segment.*
IDATIM	Image Date & Time This field shall contain the time (UTC) of the image acquisition.	14	BCS-N *CCYYMMDDhhmmss*	R	*Date/Time that best reflects the currency of the elevation postings. Typically the date/time the sensor acquired the data from which the elevation postings were derived.*
TGTID	Target ID This field shall contain the identification of the primary target.	17	BCS-A (17 space characters)	<R>	17 BCS spaces (0x20)
IID2	Image IID2 This field contains the identification of additional information about the image.	80	ECS-A *HRELLyyyymmdd*	R	*Unique identifier for the DTEM Post Height Segment. This MUST match the corresponding value found in the PIAPRD TRE field ATEXT of the file header.*
ISCLAS	Image Security Classification	1	ECS-A T, S, C, R, U	R [PSG]	*For fields ISCLAS through ISCTLN, consult Production Specific Guidance (PSG) for applicable security field population values.*
ISCLSY	Image Security Classification System	2	ECS-A US Note: this field may contain two space characters when the FSCLAS value is 'U'.	<R> [PSG]	*Refer to MIL-STD-2500C for general description of these fields. Consult current security guidelines at the time of production to determine proper markings.*
ISCODE	Image Codewords	11	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
ISCTLH	Image Control and Handling	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISREL	Image Releasing Instructions	20	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCTP	Image Declassification Type	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCDT	Image Declassification Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCXM	Image Declassification Exemption	4	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDG	Image Downgrade	1	BCS-A S, C, R	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDGDT	Image Downgrade Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCLTX	Image Downgrade Text	43	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCATP	Image Classification Authority Type	1	ECS-A O, D, M	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCAUT	Image Classification Authority	40	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRSN	Image Classification Reason	1	ECS-A A through G	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRDT	Image Security Source Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCTLN	Image Security Control Number	15	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ENCRYP	Encryption This field shall contain the value BCS zero (0x30).	1	BCS-N 0	R	*"0" HRE data is not encrypted.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
ISORCE	Image Source This field shall contain a description of the source of the image.	42	ECS-A	<R> [PSG]	*The general type of the collection source of the data; such as LIDAR, IFSAR, SAR, or EO for sensor-based sources..* **When classified, the description shall be preceded by the classification, including codewords.*
NROWS	Number of Significant Rows in Image This field shall contain the total number of rows of significant pixels in the in the image.	8	BCS-N 00000001 to 99999999	R	*Number of rows in the DTEM.*
NCOLS	Number of Significant Columns in Image This field shall contain the total number of columns of significant pixels in the image.	8	BCS-N 00000001 to 99999999	R	*Number of columns in the DTEM.*
PVTYPE	Pixel Value Type This field shall contain an indicator of the type of computer representation used for the value for each pixel for each band in the image.	3	BCS-A R, SI	R	*"R" – indicating 'real' for the HRELL case.* *"SI" – indicating 'signed integer' for the HREG case.*
IREP	Image Representation This field shall contain a valid indicator of the processing required in order to display an image.	8	BCS-A NODISPLY	R	*"NODISPLY" Indicating data not intended for display.*
ICAT	Image Category This field shall contain a valid indicator of the specific category of image, raster or grid data.	8	BCS-A DTEM	R	*"DTEM"- indicating Matrix Data (elevation). The value 'DTEM' shall be followed by 4 BCS spaces (0x20).*
ABPP	Actual Bits-Per-Pixel Per Band This field contains the number of significant bits for the value in each band of each pixel without compression.	2	BCS-N 16, 32	R	*16 when Signed Integer 32 when Real*
PJUST	Pixel Justification When ABPP is not equal to NBPP, this field indicates whether the significant bits are left justified or right justified.	1	BCS-A R	R	*"R" – indicating Right Justified*
ICORDS	Image Coordinate System This field shall contain a valid code indicating the type of coordinate system used for providing an approximate location of the image in the Image Geographic Location field (IGEOLO).	1	BCS-A D	R	*"D"- indicating decimal degrees.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IGEOLO	Image Geographic Location This field shall contain an approximate geographic location, in terms of corner locations, of the image in the coordinate system specified in the ICORDS field.	60	BCS-N *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd*	C	*Coordinates of the footprint of the DTEM.* *Format:* *“±dd.ddd□ddd.ddd”* *(repeating a total of four times)* *Note: the coordinates provided here are approximate and intended to support discovery and cataloguing of the dataset and not intended for analytical purposes. For data positioning and analysis, refer to the polygon extents provided in the XML DATA CONTENT DES*
NICOM	Number of Image Comments This field shall contain the number of image comment fields to follow.	1	BCS-N 0	R	*“0” – indicating no optional comment fields.*
IC	Image Compression This field contains a valid code indicating the form of compression used in representing the image data.	2	BCS-A NC, NM	R [PSG]	*“NC” – indicating Not Compressed.* *“NM” – indicating use of a pixel mask table.*
NBANDS	Number of Bands This field shall contain the number of data bands within the specified image.	1	BCS-A 1	R	*“1” – indicating one band (DTEM Post Height)*
IREPBAND1	1st Band Representation This field contains a valid indicator of the interpretation of the 1st band.	2	BCS-A (2 space characters)	<C>	*Default – BCS Spaces*
ISUBCAT1	1st Band Significance for Image Category This field provides the significance of the 1st band of the image.	6	BCS-A M	<R>	*“M” Terrain elevation values are in meters.*
IFC1	1st Band Image Filter Condition This field shall contain the value N (to represent none).	1	BCS-A N	R	*“N” – indicating no band filter condition*
IMFLT1	1st Band Standard Image Filter Code Reserved for future use.	3	BCS-A (3 space characters)	<R>	*Default – BCS Spaces*
NLUTS1	Number of Look-up Tables for the 1st Band This field shall contain the number of LUTs associated with the nth band of the image.	1	BCS-A 0	<R>	*“0” – indicating the number of lookup tables*
ISYNC	Image Sync Code This field shall contain BCS zero (0x30)	1	BCS-N 0	R	*“0” – no sync code*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IMODE	Image Mode This field shall contain an indicator of whether the image bands are stored sequentially, or band interleaved by block, or band interleaved by pixel, or band interleaved by row.	1	BCS-A B	R	*"B" – indicating data is stored band interleaved by block.*
NBPR	Number of Blocks per Row This field shall contain the number of image blocks in a row of blocks in the horizontal direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per row*
NBPC	Number of Blocks per Column This field shall contain the number of image blocks in a column of blocks in the vertical direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per column*
NPPBH	Number of Pixels per Block Horizontal This field shall contain the number of pixels horizontally for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of rows of the DTEM. Use 'large block' option (value = '0000') when number of rows is greater than 8192 and designates that the number of pixels vertically is specified by the value in NROWS.*
NPPBV	Number of Pixels per Block Vertical This field shall contain the number of pixels vertically for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of columns of the DTEM. Use 'large block' option (value = '0000') when number of columns is greater than 8192 and designates that the number of pixels vertically is specified by the value in NCOLS.*
NBPP	Number of Bits per Pixel per Band This field shall contain the number of storage bits used for the value from each component of a pixel value.	2	BCS-N 16, 32	R	*16 when Signed Integer* *32 when Real*
IDLVL	Display Level This field shall contain a valid value that indicates the graphic display level of the image relative to the other displayed file components.	3	BCS-N 001	R	*"001" – for the IM with the DTEM data.*
IALVL	Attachment Level This field shall contain a valid value that indicates the attachment level of the image.	3	BCS-N 000	R	*"000" – for the IM with the DTEM data.*
ILOC	Image Location This field shall contain the location of the first pixel of the first line of the image.	10	BCS-N 0000000000	R	*"0000000000"*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IMAG	Image Magnification This field shall contain the magnification factor of the image relative to the original source.	4	BCS-A 1.0	R	*"1.0 "*
UDIDL	User defined image data length A value of BCS zeros (0x30) shall denote that no TREs are included in the UDID field.	5	BCS-N 00000	R	*"00000" No TREs are included.*
IXSHDL	Extended subheader data length A value of BCS zeros (0x30) shall denote that no TREs are included in the IXSHD field.	5	BCS-N 00000	R	*"00000" No TREs are included.*

A.5.3 Image Data Mask

An image data mask structure follows the image subheader when the Image Compression Field value is "NM". The image data mask identifies those data blocks containing one or more instances of a specified data value that requires special interpretation. The numerical value of the special data value is specified by the NITF Image Data Mask Table, Pad Output Pixel Code (TPXCD) field. The designated special value can be located anywhere inside the significant image pixels defined by NROWS and NCOLS, and therefore impact the interpretation of the data. For HRE, the image data mask designates the "no-data value" used to indicate that a valid value is missing.

The structure of the image data mask is shown in Table A-4. When applicable, the image data mask is used with the HRE Post Height image subheader, the Random Error Scale Factors by Post image subheader, the Random Error Covariance by Post image subheader, and the Random Error Correlation Coefficients by Post image subheader.

Table A-4 Image Data Mask Table

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IMDATOFF	Blocked Image Data Offset. This field is included if the IC value contains M. It identifies the offset from the beginning of the Image Data Mask to the first byte of the blocked image data.	4	Unsigned binary integer 0 to 2^{32} -1 0x0000000F or 0x00000010 or 0x00000012 and 4 bytes per each block in image segment	C	Unsigned binary integer: *The offsets (decimal) are: 8 or 16 (PVTYPE SI), or 18 (PVTYPE R) plus 4 bytes per each block in image segment.*
BMRLNTH	Block Mask Record Length. This field is included if the IC value contains M. It identifies the length of each Block Mask Record (BMRnBNDm) in bytes.	2	Unsigned binary integer 0x0000	C	*0x0000 denotes that no Block Mask Records are recorded.*
TMRLNTH	Pad Pixel Mask Record Length. This field is included if the IC value contains M. It identifies the length of each Pad Pixel Mask Record in bytes. When present, the length of each Pad Pixel Mask Record is 4 bytes. The total length of the Pad Pixel Mask Records is equal to TMRLN	2	Unsigned binary integer; 0x0004	C	*0x0004 denotes that Pad Pixel Mask Records (4 bytes each) are present.*
TPXCDLNTH	Pad Output Pixel Code Length. This field is included if the IC value contains M. It identifies the length in bits of the Pad Output Pixel Code.	2	Unsigned binary integer 0x0008 0x0010 0x0020	C	*Length must be as specified in NBPP for the applicable image segment.* *Allowed NBPP values (decimal) include:* *08, 16, and 32.*
TPXCD	Pad Output Pixel Code. This field is included if the IC value contains M and TPXCDLNTH is not zeros (0x0000). It contains the output pixel code that represents a pad pixel in the image. This value is unique within the image, and allows the user to identify pad pixels. The pad output pixel code length is determined by TPXCDLNTH.	1 or 2 or 4	For PVTYPE=SI and NBPP=08: 0x81 For PVTYPE=SI and NBPP=16: 0x8001 For PVTYPE=R and NBPP=32: 0xFFFFFFFF	C	*The SIZE (in bytes) of the field is determined by the NBPP value:* *1 when NBPP=08* *2 when NBPP=16* *4 when NBPP=32* *The designated 'no-data' values (decimal) are:* *8-bit INT: -127* *16-bit SI: -32767* *32-bit R: 'Not a number'*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
TMRnBNDm	Pad Pixel n, Band m. This field shall contain the nth Pad Pixel Mask Record for band m. It is recorded/transmitted only if the TMRLNTH field does not contain zeros (0x0000). The field shall contain an offset in bytes from the beginning of the Blocked Image Data to the first byte of block n of the image data of band m if block n contains pad pixels, or the default value 0xFFFFFFFF to indicate that this block does not contain pad pixels.	4	Unsigned binary integer 0xnnnnnnnn	C	*For IMODEs B and P: Increment n only; m is always 1.*

A.6 Rigorous Error Propagation Regions

A.6.1 Rigorous Error Propagation Regions

This image segment is comprised of the standard NITF 2.10 Image Subheader information and rigorous error propagation post-by-post region definition data. This is an optional image segment, since the regions may also be defined by specifying polygon boundaries in the XML_DATA_CONTENT DES. The DES specifies which of these two methods of defining the regions is being used. Regions (a minimum of one) are always defined for error propagation metadata since this is how the systematic error covariance data is specified. In addition, the regions can be used in defining the random error nominal covariance terms.

A.6.2 Image Subheader

This section describes the fields and contents within the IM subheader. For the rigorous error propagation region definition, this IM subheader will contain the values designated in Table A-5. Metadata associated with the rigorous error propagation region data is contained in the XML_DATA_CONTENT DES.

Table A-5 Error Propagation Regions Image Subheader Format

(Type “R”=Required, “C” = Conditional, “<>” BCS Spaces allowed for entire field)

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IM	File Part Type This field shall contain the characters “IM” to identify the subheader as an image subheader.	2	BCS-A IM	R	*“IM”* .

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IID1	Image ID1 This field shall contain a valid alphanumeric identification code associated with the image	10	BCS-A *EP_REGIONS*	R	*Short name that identifies the error propagation regions segment – "EP_REGIONS"*
IDATIM	Image Date & Time This field shall contain the time (UTC) of the image acquisition.	14	BCS-N *DDHHMMSSZMONYY*	R	*Date/Time that this image segment was created*
TGTID	Target ID This field shall contain the identification of the primary target.	17	BCS-A (17 space characters)	<R>	*Default – BCS Spaces*
IID2	Image IID2 This field contains the identification of additional information about the image.	80	ECS-A *REGLLyyyymmdd*	R	*Unique identifier for the rigorous error propagation Regions definition Segment. This MUST match the corresponding value found in the PIAPRD TRE field ATEXT of the file header.*
ISCLAS	Image Security Classification This field shall contain a valid value representing the classification level of the image. Valid values are T, S, C, R, and U.	1	ECS-A T, S, C, R, U	R [PSG]	*For fields ISCLAS through ISCTLN, consult Production Specific Guidance (PSG) for applicable security field population values.*
ISCLSY	Image Security Classification System This field shall contain valid values indicating the national or multinational security system used to classify the image. Country Codes per FIPS 10-4 shall be used to indicate national security systems; codes found in DIAM 65-19 shall be used to indicate multinational security systems.	2	ECS-A US Note: this field may contain two space characters when the FSCLAS value is 'U'.	<R> [PSG]	*Refer to MIL-STD-2500C for general description of these fields. Consult current security guidelines at the time of production to determine proper markings.*
ISCODE	Image Codewords	11	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCTLH	Image Control and Handling	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISREL	Image Releasing Instructions	20	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCTP	Image Declassification Type	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCDT	Image Declassification Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
ISDCXM	Image Declassification Exemption	4	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDG	Image Downgrade	1	ECS-A S, C, R	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDGDT	Image Downgrade Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCLTX	Image Downgrade Text	43	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCATP	Image Classification Authority Type	1	ECS-A O, D, M	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCAUT	Image Classification Authority	40	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRSN	Image Classification Reason	1	ECS-A A through G	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRDT	Image Security Source Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCTLN	Image Security Control Number	15	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ENCRYP	Encryption This field shall contain the value BCS zero (0x30).	1	BCS-N 0	R	*"0"* *Not encrypted.*
ISORCE	Image Source This field shall contain a description of the source of the image.	42	BCS-A	<R> [PSG]	*The source of the matrix data.* **When classified, the description shall be preceded by the classification, including codewords.*
NROWS	Number of Significant Rows in Image This field shall contain the total number of rows of significant pixels in the in the image.	8	BCS-N 00000001 to 99999999	R	*Number of rows in the region data. This will match exactly the number or rows specified in the associated DTEM.*
NCOLS	Number of Significant Columns in Image This field shall contain the total number of columns of significant pixels in the image.	8	BCS-N 00000001 to 99999999	R	*Number of columns in the region data. This will match exactly the number or columns specified in the associated DTEM.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
PVTYPE	Pixel Value Type This field shall contain an indicator of the type of computer representation used for the value for each pixel for each band in the image.	3	BCS-A INT	R	*"INT" – indicating integer*
IREP	Image Representation This field shall contain a valid indicator of the processing required in order to display an image.	8	BCS-A NODISPLY	R	*"NODISPLY" Indicating data not intended for display.*
ICAT	Image Category This field shall contain a valid indicator of the specific category of image, raster or grid data.	8	BCS-A MATR	R	"MATR"*- indicating Matrix Data*
ABPP	Actual Bits-Per-Pixel Per Band This field contains the number of significant bits for the value in each band of each pixel without compression.	2	BCS-N 08	R	*08 (region numbers are integers)*
PJUST	Pixel Justification When ABPP is not equal to NBPP, this field indicates whether the significant bits are left justified or right justified.	1	BCS-A R	R	*"R" – indicating Right Justified*
ICORDS	Image Coordinate System This field shall contain a valid code indicating the type of coordinate system used for providing an approximate location of the image in the Image Geographic Location field (IGEOLO)	1	BCS-A D	R	*"D"- indicating decimal degrees.*
IGEOLO	Image Geographic Location This field shall contain an approximate geographic location, in terms of corner locations, of the image in the coordinate system specified in the ICORDS field.	60	BCS-N *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd*	R	*Coordinates of the footprint of the region data. This will match the corresponding footprint of the HRE DTEM Post Heights Segment.* *Format: "±dd.ddd±ddd.ddd" (repeating a total of four times)*
NICOM	Number of Image Comments This field shall contain the number of image comment fields to follow.	1	BCS-N 0	R	*"0" (no comment fields)*
IC	Image Compression This field contains a valid code indicating the form of compression used in representing the image data.	2	BCS-A NC	R	*"NC" – indicating Not Compressed*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
NBANDS	Number of Bands This field shall contain the number of data bands within the specified image.	1	BCS-A 1	R	*"1" – indicating one band (Post-by-Post region identifier)*
IREPBAND1	1st Band Representation This field contains a valid indicator of the interpretation of the nnth band.	2	BCS-A (2 space characters)	<C>	*Default – BCS Spaces*
ISUBCAT1	1st Band Significance for Image Category This field provides the significance of the nnth band of the image.	6	BCS-A (6 space characters)	<R>	*Fill with BCS spaces*
IFC1	1st Band Image Filter Condition This field shall contain the value N (to represent none).	1	BCS-A N	R	*"N" – indicating no band filter condition*
IMFLT1	1st Band Standard Image Filter Code Reserved for future use.	3	BCS-A (3 space characters)	<R>	*Default – BCS Spaces*
NLUTS1	Number of Look-up Tables for the 1st Band This field shall contain the number of LUTs associated with the nth band of the image.	1	BCS-A 0	<R>	*"0" – indicating the number of lookup tables*
ISYNC	Image Sync Code This field shall contain BCS zero (0x30)	1	BCS-N 0	R	*"0" – no sync code*
IMODE	Image Mode This field shall contain an indicator of whether the image bands are stored sequentially, or band interleaved by block, or band interleaved by pixel, or band interleaved by row.	1	BCS-A B	R	*"B" – indicating data is stored band interleaved by block.*
NBPR	Number of Blocks per Row This field shall contain the number of image blocks in a row of blocks in the horizontal direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per row*
NBPC	Number of Blocks per Column This field shall contain the number of image blocks in a column of blocks in the vertical direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per column*
NPPBH	Number of Pixels per Block Horizontal This field shall contain the number of pixels horizontally for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of rows of the DTEM. Use 'large block' option (value = '0000') when number of rows is greater than 8192 and designates that the number of pixels vertically is specified by the value in NROWS.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
NPPBV	Number of Pixels per Block Vertical This field shall contain the number of pixels vertically for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of columns of the DTEM. Use 'large block' option (value = '0000') when number of columns is greater than 8192 and designates that the number of pixels vertically is specified by the value in NCOLS.*
NBPP	Number of Bits per Pixel per Band This field shall contain the number of storage bits used for the value from each component of a pixel value.	2	BCS-N 08	R	*"08" – Number of bits per pixel per band*
IDLVL	Display Level This field shall contain a valid value that indicates the graphic display level of the image relative to the other displayed file components.	3	BCS-N 002	R	*"002"*
IALVL	Attachment Level This field shall contain a valid value that indicates the attachment level of the image.	3	BCS-N 001	R	*"001" – indicating that the region data segment (002) is attached to the HRE DTEM Post Height segment (001)*
ILOC	Image Location This field shall contain the location of the first pixel of the first line of the image.	10	BCS-N 0000000000	R	*"0000000000"*
IMAG	Image Magnification This field shall contain the magnification factor of the image relative to the original source.	4	BCS-A 1.0	R	*"1.0 "*
UDIDL	User defined image data length	5	BCS-N 00000	R	*"00000" No TREs are included.*
IXSHDL	Extended subheader data length	5	BCS-N 00000	R	*"00000" No TREs are included.*

A.7 Rigorous Error Propagation Random Error Scale Factors By Post

A.7.1 Random Error Scale Factors By Post

This image segment is comprised of the standard NITF 2.1 Image Subheader information and random error scale factors by post data. These scale factors are used in conjunction with region by region nominal random error covariance matrices defined in the XML_DATA_CONTENT DES.

A.7.2 Image Subheader

This section describes the fields and contents within the IM subheader. For the random error scale factors by post data, this IM subheader will contain the values designated in Table A-6. Metadata associated with the random error scale factors by post data is contained in the XML_DATA_CONTENT DES.

Table A-6 Random Error Post Scale Factors Image Subheader

(Type "R"=Required, "C" = Conditional, "<>" BCS Spaces allowed for entire field)

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IM	File Part Type This field shall contain the characters "IM" to identify the subheader as an image subheader.	2	BCS-A IM	R	*"IM"*
IID1	Image ID1 This field shall contain a valid alphanumeric identification code associated with the image	10	BCS-A RE_POST_SF	R	*Short name that identifies this segment – "RE_POST_SF*
IDATIM	Image Date & Time This field shall contain the time (UTC) of the image acquisition.	14	BCS-N *DDHHMMSSZMONYY*	R	*Date/Time that the random error scale factor data was created*
TGTID	Target ID This field shall contain the identification of the primary target.	17	BCS-A (17 space characters)	<R>	*Default – BCS Spaces*
IID2	Image IID2 This field contains the identification of additional information about the image.	80	ECS-A RSFLLyyyymmdd	<R>	*Unique identifier for the Random Error Scale factors Segment. This MUST match the corresponding value found in the PIAPRD TRE field ATEXT of the file header.*
ISCLAS	Image Security Classification	1	ECS-A T, S, C, R, U	R [PSG]	*For fields ISCLAS through ISCTLN, consult Production Specific Guidance (PSG) for applicable security field population values.*
ISCLSY	Image Security Classification System	2	ECS-A US Note: this field may contain two space characters when the FSCLAS value is 'U'.	<R> [PSG]	*Refer to MIL-STD-2500C for general description of these fields. Consult current security guidelines at the time of production to determine proper markings.*
ISCODE	Image Codewords	11	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCTLH	Image Control and Handling	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
ISREL	Image Releasing Instructions	20	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCTP	Image Declassification Type	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCDT	Image Declassification Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCXM	Image Declassification Exemption	4	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDG	Image Downgrade	1	ECS-A S, C, R	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDGDT	Image Downgrade Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCLTX	Image Downgrade Text	43	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCATP	Image Classification Authority Type	1	ECS-A O, D, M	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCAUT	Image Classification Authority	40	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRSN	Image Classification Reason	1	ECS-A A through G	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRDT	Image Security Source Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCTLN	Image Security Control Number	15	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ENCRYP	Encryption This field shall contain the value BCS zero (0x30).	1	BCS-N 0	R	*"0"* *Not encrypted.*
ISORCE	Image Source This field shall contain a description of the source of the image.	42	BCS-A	<R> [PSG]	*The source of the matrix data.* **When classified, the description shall be preceded by the classification, including codewords.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
NROWS	Number of Significant Rows in Image This field shall contain the total number of rows of significant pixels in the in the image.	8	BCS-N *00000001 to 99999999.*	R	*Number of rows in the random error scale factor data. This will match exactly the number or rows specified in the associated DTEM.*
NCOLS	Number of Significant Columns in Image This field shall contain the total number of columns of significant pixels in the image.	8	BCS-N *00000001 to 99999999*	R	*Number of columns in the random error scale factor data. This will match exactly the number or columns specified in the associated DTEM.*
PVTYPE	Pixel Value Type This field shall contain an indicator of the type of computer representation used for the value for each pixel for each band in the image.	3	BCS-A R	R	*"R" – indicating real*
IREP	Image Representation This field shall contain a valid indicator of the processing required in order to display an image.	8	BCS-A NODISPLY	R	*"NODISPLY" Indicating data not intended for display.*
ICAT	Image Category This field shall contain a valid indicator of the specific category of image, raster or grid data.	8	BCS-A MATR	R	*"MATR"- indicating Matrix Data*
ABPP	Actual Bits-Per-Pixel Per Band This field contains the number of significant bits for the value in each band of each pixel without compression.	2	BCS-N 32	R	*32 (scale factorsare real numbers)*
PJUST	Pixel Justification When ABPP is not equal to NBPP, this field indicates whether the significant bits are left justified or right justified.	1	BCS-A R	R	*"R" – indicating Right Justified*
ICORDS	Image Coordinate System This field shall contain a valid code indicating the type of coordinate system used for providing an approximate location of the image in the Image Geographic Location field (IGEOLO)	1	BCS-A D	R	*"D"- indicating decimal degrees.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IGEOLO	Image Geographic Location This field shall contain an approximate geographic location, in terms of corner locations, of the image in the coordinate system specified in the ICORDS field.	60	BCS-N *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd*	R	*Coordinates of the footprint of the random error scale factor data. This will match the corresponding footprint of the DTEM Post Heights, IM Segments.* *Format: "±dd.ddd±ddd.ddd" (repeating a total of four times)*
NICOM	Number of Image Comments This field shall contain the number of image comment fields to follow.	1	BCS-N 0	R	*"0" (no comment fields)*
IC	Image Compression This field contains a valid code indicating the form of compression used in representing the image data.	2	BCS-A NC, NM	R [PSG]	*"NC" – indicating Not Compressed* *"NM" – indicating use of a pixel mask table.*
NBANDS	Number of Bands This field shall contain the number of data bands within the specified image.	1	BCS-A 1	R	*"1" – indicating one band (random error scale factor data)*
IREPBAND1	1^{st} Band Representation This field contains a valid indicator of the interpretation of the nn^{th} band.	2	BCS-A (2 space characters)	<C>	*Default – BCS Spaces*
ISUBCAT1	1^{st} Band Significance for Image Category This field provides the significance of the nn^{th} band of the image.	6	BCS-A (6 space characters)	<R>	*Fill with BCS spaces*
IFC1	1^{st} Band Image Filter Condition This field shall contain the value N (to represent none).	1	BCS-A N	R	*"N" – indicating no band filter condition*
IMFLT1	1^{st} Band Standard Image Filter Code Reserved for future use.	3	BCS-A (3 space characters)	<R>	*Default – BCS Spaces*
NLUTS1	Number of Look-up Tables for the 1^{st} Band This field shall contain the number of LUTs associated with the nth band of the image.	1	BCS-A 0	<R>	*"0" – indicating the number of lookup tables*
ISYNC	Image Sync Code This field shall contain BCS zero (0x30)	1	BCS-N 0	R	*"0" – no sync code*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IMODE	Image Mode This field shall contain an indicator of whether the image bands are stored sequentially, or band interleaved by block, or band interleaved by pixel, or band interleaved by row.	1	BCS-A B	R	*"B" – indicating data is stored band interleaved by block.*
NBPR	Number of Blocks per Row This field shall contain the number of image blocks in a row of blocks in the horizontal direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per row*
NBPC	Number of Blocks per Column This field shall contain the number of image blocks in a column of blocks in the vertical direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per column*
NPPBH	Number of Pixels per Block Horizontal This field shall contain the number of pixels horizontally for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of rows of the DTEM. Use 'large block' option (value = '0000') when number of rows is greater than 8192 and designates that the number of pixels vertically is specified by the value in NROWS.*
NPPBV	Number of Pixels per Block Vertical This field shall contain the number of pixels vertically for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of columns of the DTEM. Use 'large block' option (value = '0000') when number of columns is greater than 8192 and designates that the number of pixels vertically is specified by the value in NCOLS.*
NBPP	Number of Bits per Pixel per Band This field shall contain the number of storage bits used for the value from each component of a pixel value.	2	BCS-N 32	R	*"32" – Number of bits per pixel per band*
IDLVL	Display Level This field shall contain a valid value that indicates the graphic display level of the image relative to the other displayed file components.	3	BCS-N 003	R	*"003"*
IALVL	Attachment Level This field shall contain a valid value that indicates the attachment level of the image.	3	BCS-N 001	R	*"001" – indicating that the scale factor segment (003) is attached to the DTEM Post segment (001)*
ILOC	Image Location This field shall contain the location of the first pixel of the first line of the image.	10	BCS-N 0000000000	R	*"0000000000"*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IMAG	Image Magnification This field shall contain the magnification factor of the image relative to the original source.	4	BCS-A 1.0	R	*"1.0 "*
UDIDL	User defined image data length	5	BCS-N 00000	R	*"00000" No TREs are included.*
IXSHDL	Extended subheader data length	5	BCS-N 00000	R	*"00000" No TREs are included.*

A.8 Rigorous Error Propagation Random Error Covariance By Post

A.8.1 Random Error Covariance By Post

This image segment is comprised of the standard NITF 2.10 image subheader information and the random error covariance by post data. The random error covariance data are input as standard deviation terms that when squared, make up the diagonal terms of the random error covariance matrices. The presence of this image segment is defined in the accompanying XML_DATA_CONTENT DES. When this image segment is being used to specify a per-post random error covariance matrix, the random error covariance by post image segment is always accompanied by a random error correlation coefficients by post image segment (Section 9). Dividing the random error covariance matrix terms between two image segments permits different levels of precision to be specified for each in an attempt to minimize file size.

A.8.2 Image Subheader

This section describes the fields and contents within the IM subheader. For the random error covariance by post data, this IM subheader will contain the values designated in Table A-7. Metadata associated with the random error covariance by post data is contained in the XML_DATA_CONTENT DES.

Table A-7 Random Error Covariance Image Subheader

(Type "R"=Required, "C" = Conditional, "<>" BCS Spaces allowed for entire field)

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IM	File Part Type This field shall contain the characters "IM" to identify the subheader as an image subheader.	2	BCS-A IM	R	*"IM"*
IID1	Image ID1 This field shall contain a valid alphanumeric identification code associated with the image	10	BCS-A COVARIANCE	R	*Short name that identifies this segment – "COVARIANCE"*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IDATIM	Image Date & Time This field shall contain the time (UTC) of the image acquisition.	14	BCS-N *DDHHMMSSZMONYY*	R	*Date/Time that the random error covariance data was created*
TGTID	Target ID This field shall contain the identification of the primary target.	17	BCS-A (17 space characters)	<R>	*Default – BCS Spaces*
IID2	Image IID2 This field contains the identification of additional information about the image.	80	ECS-A COVLLyyyymmdd	<R>	*Unique identifier for the Random Error Covariance Segment. This MUST match the corresponding value found in the PIAPRD TRE field ATEXT of the file header.*
ISCLAS	Image Security Classification	1	ECS-A T, S, C, R, U	R [PSG]	*For fields ISCLAS through ISCTLN, consult Production Specific Guidance (PSG) for applicable security field population values.*
ISCLSY	Image Security Classification System	2	ECS-A US Note: this field may contain two space characters when the FSCLAS value is 'U'.	<R> [PSG]	*Refer to MIL-STD-2500C for general description of these fields. Consult current security guidelines at the time of production to determine proper markings.*
ISCODE	Image Codewords	11	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCTLH	Image Control and Handling	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISREL	Image Releasing Instructions	20	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCTP	Image Declassification Type	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCDT	Image Declassification Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCXM	Image Declassification Exemption	4	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDG	Image Downgrade	1	ECS-A S, C, R	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDGDT	Image Downgrade Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
ISCLTX	Image Downgrade Text	43	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCATP	Image Classification Authority Type	1	ECS-A O, D, M	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCAUT	Image Classification Authority	40	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRSN	Image Classification Reason	1	ECS-A A through G	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRDT	Image Security Source Date	8	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCTLN	Image Security Control Number	15	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ENCRYP	Encryption This field shall contain the value BCS zero (0x30).	1	BCS-N 0	R	*"0"* *Not encrypted.*
ISORCE	Image Source This field shall contain a description of the source of the image.	42	BCS-A	<R> [PSG]	*The source of the matrix data.* **When classified, the description shall be preceded by the classification, including codewords.*
NROWS	Number of Significant Rows in Image This field shall contain the total number of rows of significant pixels in the in the image.	8	BCS-N 00000001 to 99999999	R	*Number of rows in the random error covariance data. This will match exactly the number or rows specified in the associated DTEM.*
NCOLS	Number of Significant Columns in Image This field shall contain the total number of columns of significant pixels in the image.	8	BCS-N 00000001 to 99999999	R	*Number of columns in the random error covariance data. This will match exactly the number or columns specified in the associated DTEM.*
PVTYPE	Pixel Value Type This field shall contain an indicator of the type of computer representation used for the value for each pixel for each band in the image.	3	BCS-A R	R	*"R" – indicating real*
IREP	Image Representation This field shall contain a valid indicator of the processing required in order to display an image.	8	BCS-A NODISPLY	R	*"NODISPLY"* *Indicating data not intended for display.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
ICAT	Image Category This field shall contain a valid indicator of the specific category of image, raster or grid data.	8	BCS-A MATR	R	*"MATR"- indicating Matrix Data*
ABPP	Actual Bits-Per-Pixel Per Band This field contains the number of significant bits for the value in each band of each pixel without compression.	2	BCS-N 32	R	*32 (random error covariances are a real number)*
PJUST	Pixel Justification When ABPP is not equal to NBPP, this field indicates whether the significant bits are left justified or right justified.	1	BCS-A R	R	*"R" – indicating Right Justified*
ICORDS	Image Coordinate System This field shall contain a valid code indicating the type of coordinate system used for providing an approximate location of the image in the Image Geographic Location field (IGEOLO)	1	BCS-A D	R	*"D"- indicating decimal degrees.*
IGEOLO	Image Geographic Location This field shall contain an approximate geographic location, in terms of corner locations, of the image in the coordinate system specified in the ICORDS field.	60	BCS-N *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd*	R	*Coordinates of the footprint of the random error covariance data. This will match the corresponding footprint of the DTEM Post Heights, IM Segments.* *Format: "±dd.ddd±ddd.ddd" (repeating a total of four times)*
NICOM	Number of Image Comments This field shall contain the number of image comment fields to follow.	1	BCS-N 0	R	*"0" (no comment fields)*
IC	Image Compression This field contains a valid code indicating the form of compression used in representing the image data.	2	BCS-A NC, NM	R [PSG]	*"NC" – indicating Not Compressed* *"NM" – indicating use of a pixel mask table.*
NBANDS	Number of Bands This field shall contain the number of data bands within the specified image.	1	BCS-A 3	R	*"3" – indicating three bands (random error covariance data)*
IREPBANDn	n^{th} Band Representation This field contains a valid indicator of the interpretation of the n^{th} band.	2	BCS-A (2 space characters)	<C>	*Default – BCS Spaces*
ISUBCATn	n^{th} Band Significance for Image Category This field provides the significance of the n^{th} band of the image.	6	BCS-A (6 space characters)	<R>	*Fill with BCS spaces*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IFCn	n^th^ Band Image Filter Condition This field shall contain the value N (to represent none).	1	BCS-A N	R	*"N" – indicating no band filter condition*
IMFLTn	n^th^ Band Standard Image Filter Code Reserved for future use.	3	BCS-A (3 space characters)	<R>	*Default – BCS Spaces*
NLUTSn	Number of Look-up Tables for the n^th^ Band This field shall contain the number of LUTs associated with the nth band of the image.	1	BCS-A 0	<R>	*"0" – indicating the number of lookup tables*
ISYNC	Image Sync Code This field shall contain BCS zero (0x30)	1	BCS-N 0	R	*"0" – no sync code*
IMODE	Image Mode This field shall contain an indicator of whether the image bands are stored sequentially, or band interleaved by block, or band interleaved by pixel, or band interleaved by row.	1	BCS-A P	R	*"P" – indicating data is stored band interleaved by pixel.*
NBPR	Number of Blocks per Row This field shall contain the number of image blocks in a row of blocks in the horizontal direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per row*
NBPC	Number of Blocks per Column This field shall contain the number of image blocks in a column of blocks in the vertical direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per column*
NPPBH	Number of Pixels per Block Horizontal This field shall contain the number of pixels horizontally for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of rows of the DTEM. Use 'large block' option (value = '0000') when number of rows is greater than 8192 and designates that the number of pixels vertically is specified by the value in NROWS.*
NPPBV	Number of Pixels per Block Vertical This field shall contain the number of pixels vertically for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of columns of the DTEM. Use 'large block' option (value = '0000') when number of columns is greater than 8192 and designates that the number of pixels vertically is specified by the value in NCOLS.*
NBPP	Number of Bits per Pixel per Band This field shall contain the number of storage bits used for the value from each component of a pixel value.	2	BCS-N 32	R	*"32" – Number of bits per pixel per band*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IDLVL	Display Level This field shall contain a valid value that indicates the graphic display level of the image relative to the other displayed file components.	3	BCS-N 004	R	*"004"*
IALVL	Attachment Level This field shall contain a valid value that indicates the attachment level of the image.	3	BCS-N 001	R	*"001" – indicating that the random error covariance segment (004) is attached to the DTEM Post segment (001)*
ILOC	Image Location This field shall contain the location of the first pixel of the first line of the image.	10	BCS-N 0000000000	R	*"0000000000"*
IMAG	Image Magnification This field shall contain the magnification factor of the image relative to the original source.	4	BCS-A 1.0	R	*"1.0 "*
UDIDL	User defined image data length	5	BCS-N 00000	R	*"00000" No TREs are included.*
IXSHDL	Extended subheader data length	5	BCS-N 00000	R	*"00000" No TREs are included.*

A.9 Rigorous Error Propagation Random Error Correlation Coefficients By Post

A.9.1 Random Error Correlation Coefficients By Post

This image segment is comprised of the standard NITF 2.10 Image Subheader information and random error correlation coefficients by post data. The random error correlation coefficient data (when multiplied by the corresponding diagonal term standard deviations) make up the off-diagonal terms of the random error covariance matrices. The presence of this image segment is defined in the accompanying XML_DATA_CONTENT DES. When this image segment is being used to specify a per-post random error covariance matrix, the random error correlation coefficients by post image segment is always accompanied with a random error covariance by post image segment (Section 8). Dividing the random error covariance matrix terms between two image segments permits different levels of precision to be specified for each in an attempt to minimize file size.

A.9.2 Image Subheader

This section describes the fields and contents within the IM subheader. For the random error correlation coefficients by post data, this IM subheader will contain the values designated in Table A-8.

Table A-8 Random Error Correlation Coefficient Image Subheader

(Type "R"=Required, "C" = Conditional, "<>" BCS Spaces allowed for entire field)

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
IM	File Part Type This field shall contain the characters "IM" to identify the subheader as an image subheader.	2	BCS-A IM	R	*"IM"*
IID1	Image ID1 This field shall contain a valid alphanumeric identification code associated with the image	10	BCS-A COREL_COEF	R	*Short name that identifies this segment – "COREL_COEF"*
IDATIM	Image Date & Time This field shall contain the time (UTC) of the image acquisition.	14	BCS-N *DDHHMMSSZMONYY*	R	*Date/Time that the random error correlation coefficient data was created*
TGTID	Target ID This field shall contain the identification of the primary target.	17	BCS-A (17 space characters)	<R>	*Default – BCS Spaces*
IID2	Image IID2 This field contains the identification of additional information about the image.	80	ECS-A CORLLyyyymmdd	<R>	*Unique identifier for the Random Error Correlation Coefficient Segment. This MUST match the corresponding value found in the PIAPRD TRE field ATEXT of the file header.*
ISCLAS	Image Security Classification	1	ECS-A T, S, C, R, U	R [PSG]	*For fields ISCLAS through ISCTLN, consult Production Specific Guidance (PSG) for applicable security field population values.*
ISCLSY	Image Security Classification System	2	ECS-A US Note: this field may contain two space characters when the FSCLAS value is 'U'.	<R> [PSG]	*Refer to MIL-STD-2500C for general description of these fields. Consult current security guidelines at the time of production to determine proper markings.*
ISCODE	Image Codewords	11	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCTLH	Image Control and Handling	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISREL	Image Releasing Instructions	20	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCTP	Image Declassification Type	2	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
ISDCDT	Image Declassification Date	8	ECS-A *CCYYMMDD*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDCXM	Image Declassification Exemption	4	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDG	Image Downgrade	1	ECS-A S, C, R	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISDGDT	Image Downgrade Date	8	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCLTX	Image Downgrade Text	43	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCATP	Image Classification Authority Type	1	ECS-A O, D, M	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCAUT	Image Classification Authority	40	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRSN	Image Classification Reason	1	ECS-A	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCRDT	Image Security Source Date	8	ECS-A *CCYYMMDD.*	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ISCTLN	Image Security Control Number	15	ECS-A A through G	<R> [PSG]	*Consult current security guidelines at the time of production to determine proper markings.*
ENCRYP	Encryption This field shall contain the value BCS zero (0x30).	1	BCS-N 0	R	*"0"* *Not encrypted.*
ISORCE	Image Source This field shall contain a description of the source of the image.	42	BCS-A	<R> [PSG]	*The source of the matrix data.* **When classified, the description shall be preceded by the classification, including codewords.*
NROWS	Number of Significant Rows in Image This field shall contain the total number of rows of significant pixels in the in the image.	8	BCS-N 00000001 to 99999999	R	*Number of rows in the random error correlation coefficient data. This will match exactly the number or rows specified in the associated DTEM.*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
NCOLS	Number of Significant Columns in Image This field shall contain the total number of columns of significant pixels in the image.	8	BCS-N 00000001 to 99999999	R	*Number of columns in the random error correlation coefficient data. This will match exactly the number or columns specified in the associated DTEM.*
PVTYPE	Pixel Value Type This field shall contain an indicator of the type of computer representation used for the value for each pixel for each band in the image.	3	BCS-A SI	R	*"SI" – indicating signed integers. The integer values are within the range of -100 to 100 and represent percentage from -100% to 100%.*
IREP	Image Representation This field shall contain a valid indicator of the processing required in order to display an image.	8	BCS-A NODISPLY	R	*"NODISPLY"* *Indicating data not intended for display.*
ICAT	Image Category This field shall contain a valid indicator of the specific category of image, raster or grid data.	8	BCS-A MATR	R	*"MATR"- indicating Matrix Data*
ABPP	Actual Bits-Per-Pixel Per Band This field contains the number of significant bits for the value in each band of each pixel without compression.	2	BCS-N 8	R	*8 (random error correlation coefficients are SI numbers)*
PJUST	Pixel Justification When ABPP is not equal to NBPP, this field indicates whether the significant bits are left justified or right justified.	1	BCS-A R	R	*"R" – indicating Right Justified*
ICORDS	Image Coordinate System This field shall contain a valid code indicating the type of coordinate system used for providing an approximate location of the image in the Image Geographic Location field (IGEOLO)	1	BCS-A D	<R>R	*"D" – indicating decimal degrees.*
IGEOLO	Image Geographic Location This field shall contain an approximate geographic location, in terms of corner locations, of the image in the coordinate system specified in the ICORDS field.	60	BCS-N *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd* *±dd.ddd±ddd.ddd*	R	*Coordinates of the footprint of the random error correlation coefficient data. This will match the corresponding footprint of the DTEM Post Heights, IM Segments.* *Format: "±dd.ddd±ddd.ddd" (repeating a total of four times)*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
NICOM	Number of Image Comments This field shall contain the number of image comment fields to follow.	1	BCS-N 0	R	*"0" (no comment fields)*
IC	Image Compression This field contains a valid code indicating the form of compression used in representing the image data.	2	BCS-A NC, NM	R [PSG]	*"NC" – indicating Not Compressed* *"NM" – indicating use of a pixel mask table.*
NBANDS	Number of Bands This field shall contain the number of data bands within the specified image.	1	BCS-A 3	R	*"3" – indicating three bands (random error correlation coefficient data)*
IREPBANDn	n^{th} Band Representation This field contains a valid indicator of the interpretation of the n^{th} band.	2	BCS-A (2 space characters)	<C>	*Default – BCS Spaces*
ISUBCATn	n^{th} Band Significance for Image Category This field provides the significance of the n^{th} band of the image.	6	BCS-A (6 space characters)	<R>	*Fill with BCS spaces*
IFCn	n^{th} Band Image Filter Condition This field shall contain the value N (to represent none).	1	BCS-A N	R	*"N" – indicating no band filter condition*
IMFLTn	^{nth} Band Standard Image Filter Code Reserved for future use.	3	BCS-A (3 space characters)	<R>	*Default – BCS Spaces*
NLUTSn	Number of Look-up Tables for the n^{th} Band This field shall contain the number of LUTs associated with the nth band of the image.	1	BCS-A 0	<R>	*"0" – indicating the number of lookup tables*
ISYNC	Image Sync Code This field shall contain BCS zero (0x30)	1	BCS-N 0	R	*"0" – no sync code*
IMODE	Image Mode This field shall contain an indicator of whether the image bands are stored sequentially, or band interleaved by block, or band interleaved by pixel, or band interleaved by row.	1	BCS-A P	R	*"P" – indicating data is stored band interleaved by pixel.*
NBPR	Number of Blocks per Row This field shall contain the number of image blocks in a row of blocks in the horizontal direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per row*
NBPC	Number of Blocks per Column This field shall contain the number of image blocks in a column of blocks in the vertical direction.	4	BCS-N 0001 to 9999	R	*Indicates one or more blocks per column*

FIELD	NAME	SIZE	VALUE RANGE	TYPE	COMMENTS
NPPBH	Number of Pixels per Block Horizontal This field shall contain the number of pixels horizontally for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of rows of the DTEM. Use 'large block' option (value = '0000') when number of rows is greater than 8192 and designates that the number of pixels vertically is specified by the value in NROWS.*
NPPBV	Number of Pixels per Block Vertical This field shall contain the number of pixels vertically for each block.	4	BCS-N 0001-8192 Or 0000 When count>8192	R	*Number of columns of the DTEM. Use 'large block' option (value = '0000') when number of columns is greater than 8192 and designates that the number of pixels vertically is specified by the value in NCOLS.*
NBPP	Number of Bits per Pixel per Band This field shall contain the number of storage bits used for the value from each component of a pixel value.	2	BCS-N 08	R	*"8" – Number of bits per pixel per band*
IDLVL	Display Level This field shall contain a valid value that indicates the graphic display level of the image relative to the other displayed file components.	3	BCS-N 005	R	*"005"*
IALVL	Attachment Level This field shall contain a valid value that indicates the attachment level of the image.	3	BCS-N 004	R	*"004" – indicating that the random error correlation coefficient segment (004) is attached to the random error covariance segment (002)*
ILOC	Image Location This field shall contain the location of the first pixel of the first line of the image.	10	BCS-N 0000000000	R	*"0000000000"*
IMAG	Image Magnification This field shall contain the magnification factor of the image relative to the original source.	4	BCS-A 1.0	R	*"1.0 "*
UDIDL	User defined image data length	5	BCS-N 00000	R	*"00000" No TREs are included.*
IXSHDL	Extended subheader data length	5	BCS-N 00000	R	*"00000" No TREs are included.*

A.10 Additional HRE Metadata

A.10.1 XML_Data_Content Data Extension Segment (DES)

Additional Metadata associated with the DTEM data is contained in the XML_DATA_CONTENT DES. A single XML_DATA_CONTENT DES shall be included in every NITF-formatted HRE data file. This data extension segment is comprised of subheader information and XML-formatted metadata.

A.10.2 DES Subheader

The DES shall include a DES subheader (compliant with MIL-STD-2500C Section 5.8.2 and Appendix A, Table A-8) and user-defined data.

1. For the HRE Metadata, this DES subheader will contain the values designated in Table A-9.

2. DES CLEVEL assignment is detailed in Table A-10.

3. This table does not include the /security/classification fields: Fields DECLAS through DESCTLN are required and are detailed in Mil-Std-2500C and implementers should follow security guidance found in Tables A-3, A-5, A-6, A-7 and A-8 for security fields ISCLAS to ISCTLN.

Note: For the security/classification marking fields, DECLAS through DESCTLN, the field descriptions have been removed from this table since they are shown in Table 1, and defined in Mil-Std-2500C.

Table A-9 XML_Data_Content DES Subheader

R = Required, A = Alphanumeric, N = Numeric,
<> = Designated Default Value Allowed

Field	Name/Description	Size	Value Range	Type
DE	File Part Type. This field shall contain the characters DE to identify the subheader as a data extension.	2	BCS-A DE	R
DESID	Unique DES type identifier. This field shall contain XML_DATA_CONTENT	25	BCS-A XML_DATA_CONTENT	R
DESVER	Version of the data definition. This field shall contain the alphanumeric version number of the use of the Tag. The version number is assigned as part of the registration process.	2	BCS-N positive integer 01	R
DECLAS through DESCTLN	Security classification fields are defined in Mil-Std-2500C and implementers should follow security guidance found in Tables A-3, A-5, A-6, A-7 and A-8 for security fields ISCLAS to ISCTLN.	167	*For fields DECLAS through DESCTLN, consult Production Specific Guidance (PSG) for applicable security field population values.*	R [PSG]
DESSHL	DES User-defined Subheader Length This field shall contain the number of bytes in the field DESSHF. The field, DESSHF (DES User-defined Subheader Field), is comprised of the sub-fields DESCRC through DESSHABS specified below	4	BCS-N positive integer 0773	R

Field	Name/Description	Size	Value Range	Type
DESCRC	Cyclic Redundancy Check. This field contains the calculated CRC value for the content of the DESDATA field. A value of 99999 shall be used when CRC is not calculated.	5	BCS-N positive integer 999999	R
DESSHFT	XML File Type. Data in this field shall be representative of the XML File Type	8	BCS-A XML	R
DESSHDT	Date and Time. This field shall contain the time (UTC) (Zulu) of the XML file's origination in the format: YYYY-MM-DDThh:mm:ssZ, where YYYY is the year (0000-9999), MM is the month (01 to 12), DD is the day (01 to 31), T is the separator between date and time, hh is the hour (00 to 23), mm is the minute (00 to 59), and ss is the second (00 to 59). Z is the UTC time zone designator to express the time of day. The precision for recording the date and time is dictated by the user application and the field size constraint. Examples: 2007-04-12T11:45:20Z 2007-04-12T11:45Z 2007-04-12	20	BCS-A YYYY-MM-DDThh:mm:ssZ	R
DESSHRP	Responsible Party – Organization Identifier. Identification of the organization responsible for the content of the DES.	40	BCS-A National Geospatial-Intelligence Agency	R
DESSHSI	Specification Identifier. Name of the specification used for the XML data content.	60	BCS-A Implementation Profile for HRE Products	R
DESSHSV	Specification Version. Version or edition of the specification.	10	BCS-A 1.1	R
DESSHSD	Specification Date. Version or edition date for the specification. See Date and Time description above.	20	BCS-A **2014-xx-xx**	R
DESSHTN	Target Namespace. Identification of the *target namespace*, if any, designated within the XML data content. Example: http://www.w3.org/2001/XMLSchema	120	BCS-A http://www.isotc211.org/2005/gmd	R
When the content of the DES is applicable to a geographic location, at least one of the three Location elements (Polygon, Point, Identifier) shall be recorded.				

Field	Name/Description	Size	Value Range	Type
DESSHLPG	<u>Location – Polygon.</u> Five-point boundary enclosing the area applicable to the DES, expressed as the closed set of coordinates of the polygon (last point replicates first point). NOTE: For HRE, these coordinates are duplicated in the XML metadata in this DES. The coordinates are always provided as decimal degrees on WGS-84, even for HRE Level 2-8 products, which are projected to UTM. Recorded as paired latitude and longitude values in decimal degrees with no separator. Each latitude and longitude value includes an explicit ‘plus’ or ‘minus sign’. The precision for recording the values in the subheader is dictated by the field size constraint.	125	BCS-A Five pairs of longitude and latitude values. -90 to +90 latitude -180 to +360 longitude *±dd.dddddddd±ddd.dddddddd* *±dd.dddddddd±ddd.dddddddd* *±dd.dddddddd±ddd.dddddddd* *±dd.dddddddd±ddd.dddddddd* *±dd.dddddddd±ddd.dddddddd*	R
DESSHLPT	<u>Location – Point.</u> Single geographic point applicable to the DES. NOTE: This is only an approximate reference so specifying the coordinate reference system is unnecessary. Recorded as paired latitude and longitude values in decimal degrees. The precision for recording the values in the subheader is dictated by the field size constraint.	25	BCS-A -90 to +90 latitude -180 to +360 longitude *±dd.dddddddd±ddd.dddddddd* Default is ECS spaces (0x20) *HRE shall default to all spaces.*	<R>
DESSHLI	<u>Location – Identifier.</u> Identifier used to represent a geographic area. An alphanumeric value identifying an instance in the designated namespace. When this field is recorded with other than the default value, the Location Identifier Namespace URI shall also be recorded. Examples: US USA	20	BCS-A Default is ECS spaces (0x20) *HRE shall default to all spaces.*	<R>
DESSHLIN	<u>Location Identifier Namespace URI.</u> URI for the Namespace where the Location Identifier is described. Example: http://metadata.dod.mil/mdr/ns/GPAS/codelist/fips10-4/digraph http://metadata.dod.mil/mdr/ns/GPAS/codelist/iso3166-1/trigraph	120	BCS-A Default is ECS spaces (0x20) *HRE shall default to all spaces.*	<R>

Field	Name/Description	Size	Value Range	Type
DESSHABS	Abstract. Brief narrative summary of the content of the DES.	200	BCS-A High Resolution Elevation (HRE) Data consisting of a fixed resolution grid of elevation values at [m] post spacing representing a geospatial surface. *Where [m] is the applicable post spacing.* Default is ECS spaces (0x20)	<R> [PSG]
DESDATA	User-defined data field. This field shall contain the XML data. The length of this field shall not cause any other NITF field length limits to be exceeded, but is otherwise fully user-defined.	**	Metadata formatted in XML conforming to ISO/TS 19139:2007 with content as described in Annex B	R

A.11 HRE SHAPE Data

A.11.1 CSSHPA Data Extension Segment (DES)

The Shapefile DES (CSSHPA) is a general wrapper structure for an ESRI Shapefile. Inclusion of the CSSHPA DES is optional; see production specific guidance for when to include one or more instances of this DES. This data extension segment is comprised of subheader information and the three files that together constitute a Shapefile.

A.11.2 DES Subheader

The DES shall include a DES subheader (compliant with MIL-STD-2500C Section 5.8.2 and Appendix A, Table A-8) and user-defined data.

1. DES CLEVEL assignment is detailed in Table A-10.

2. This table does not include the /security/classification fields: Fields DECLAS through DESCTLN are required and are detailed in Mil-Std-2500C and implementers should follow security guidance found in Tables A-3, A-5, A-6, A-7 and A-8 for security fields ISCLAS to ISCTLN.

3. User-defined data shall consist of an ESRI Shapefile complying with the ESRI Shapefile Technical Description.

4. Nodes of shapes described in a Shapefile DES shall be expressed as latitude and longitude coordinates referenced to the WGS-84 datum only. It is acceptable to use the WGS-84 datum for Shapefiles even if the elevation or error data files are

expressed in a different datum. Shapes within a Shapefile shall be composed of a minimum of three nodes (four is preferable).

5. The datasets may contain multiple instances of the CSSHPA DES, as described below. The SHAPE_USE field of the user-defined DES subheader fields distinguishes the instances.

When accompanying HRE data, shapefiles encapsulated in the DES would typically be used to define water bodies, void areas, alternate source fill, known anomalous data or regions for error/accuracy information.

The following table defines the format of CSSHPA DES as used for HRE data.

Table A-10 CSSHPA Data Extension Segment

R = Required, A = Alphanumeric, N = Numeric,
<> = Designated Default Value Allowed

Field	Name/Description	Size	Value Range	Type
DE	File Part Type. This field shall contain the characters “DE” to identify the subheader as a data extension.	2	BCS-A DE	R
DESID	Unique DES type identifier. This field shall contain the value “CSSHPA”.	25	BCS-A CSSHPA	R
DESVER	Version of the data definition. This field shall contain the alphanumeric version number of the use of the tag. The version number is assigned as part of the registration process.	2	BCS-N positive integer 01	R
DECLAS through DESCTLN	Security classification fields are defined in MIL-STD-2500C and implementers should follow security guidance found in Tables A-3, A-5, A-6, A-7 and A-8 for security fields ISCLAS to ISCTLN.	167	*For fields DECLAS through DESCTLN, consult Production Specific Guidance (PSG) for applicable security field population values.*	R [PSG]
DESSHL	DES User-defined Subheader Length. This field shall contain the number of bytes in the field DESSHF.	4	BCS-N positive integer 0062	R
The following eight sub-fields constitute the DESSHF user-defined fields for this DES.				
SHAPE_USE	Shapefile Use. This field shall contain a value descriptive of the purpose for the Shapefile. Typical values include: WATER_BODY_SHAPE VOID_SHAPE ALTERNATE_FILL_SHAPE ANOMALOUS_SHAPE ERROR_REGION_SHAPE LAND_COVER_CLASS VERTICAL_OBSTRUCTION SURFACE_TYPE GROUND_CONTROL_POINT ….	25	BCS-A	R [PSG]

Field	Name/Description	Size	Value Range	Type
SHAPE_CLASS	Shapefile Class. Type of shapes contained within this Shapefile. E.g. POLYGON	10	BCS-A	R
SHAPE1_NAME	Shapefile1 Name. Name of first file in the Shapefile. One of three allowed values: SHP, SHX, or DBF.	3	BCS-A SHP SHX DBF	R
SHAPE1_START	Shapefile1 Start Location. Start location in bytes of the first file, expressed as an offset in the DES User-Defined Data.	6	BCS-N positive integer Generated by DES content provider.	R
SHAPE2_NAME	Shapefile2 Name. Name of second file in the Shapefile. One of three allowed values: SHP, SHX, or DBF.	3	BCS-A SHP SHX DBF	R
SHAPE2_START	Shapefile2 Start Location. Start location in bytes of the second file, expressed as an offset in the DES User-Defined Data.	6	BCS-N positive integer Generated by DES content provider.	R
SHAPE3_NAME	Shapefile3 Name. Name of third file in the Shapefile. One of three allowed values: SHP, SHX, or DBF.	3	BCS-A SHP SHX DBF	R
SHAPE3_START	Shapefile3 Start Location. Start location in bytes of the third file, expressed as an offset in the DES User-Defined Data.	6	BCS-N positive integer Generated by DES content provider.	R
DESDATA	User-defined data field. The user-defined data field shall consist of the three files which together comprise the description of an ESRI Shapefile (described in the ESRI Shapefile Technical Description). **The length of this field shall not cause any other NITF field length limits to be exceeded.	**	User defined extension with no intervening octets.	R

Annex B HRE XML Metadata Specification (Normative)

This annex provides a data dictionary for the minimum required XML metadata that is to be included in the NITF file. The list of metadata elements in Table B.1 is primarily based upon the core metadata requirements of the NSG Metadata Foundation (NMF)[1], which is a profile of ISO 19115:2003 Geographic information - Metadata. The NMF Part 3 extends the Core with metadata that describes imagery and gridded data. It is a profile of ISO 19115-2:2009 and parts of ISO 19115:2003. The NSG Metadata Implementation Specification (NMIS) – Part 2: XML Exchange Schema specifies an XML encoding of NMF metadata.

The ISO/NMF path is included with the metadata element name in Table B.1 to support mapping of HRE metadata requirements to the NMF model. The path is expressed in dot-notation, with class names (capitalized) separated from their properties (not capitalized). Properties may be either attributes or association roles. Association role names are always followed by the name of the class that they reference. The column headings in Table B.1 correspond to those used in the ISO 19115 Metadata Package Data Dictionaries.

This annex also complies with the International (DGIWG) Elevation Surface Model (ESM) for metadata requirements specific to elevation data. Adherence of XML instances to the requirements included in Table B.1 will ensure compliance with the metadata requirements of the NMF/NMIS, the ESM, and this HRE profile.

B.1 HRE Core Metadata

Table B.1 describes the minimum required discovery metadata entities and elements associated with HRE data. The table is a profile of the NSG Metadata Foundation (NMF) standard, so some classes, attributes and association roles have been hidden. For the full table, consult the NMF. The Obligation, Maximum Occurrence, and Value Domain requirement for each element is derived from NMF and/or ISO, with any additional constraints on the corresponding ESM element indicated in the table. In the Obligation column, an 'M' indicates that the metadata element is ESM mandatory. A "C" indicates that the element is ESM mandatory under the condition provided. The Max Occur column is simply an indication of whether NMF allows multiple instances of the element to be included in the metadata file. The contents of the Value Domain column indicate the allowed values for the element. For most elements, these are presented as NMF-defined basic types, complex types and codelists, but ESM-specific constraints on the domain may be specified.

[1] Developer should be aware that the NMF is still under going updates in the metadata mapping efforts and would recommend review of latest publication in development efforts as there is a potential for the mapping identified in this document may have changed.

Table B.1: XML Metadata Dictionary

	Name path	**Definition**	**Obligation**	**Max Occur**	**Data Type**	**Domain / Business Rule**
1	**Resource title** MD_Metadata.identificationInfo.citation.CI_Citation.title	name by which the cited resource is known	M	1	Character String	Name of the NITF file containing the elevation values
2	**Resource Identifier** MD_Metadata.identificationInfo.citation.CI_Citation.identifier.MD_Identifier.code	value uniquely identifying an object within a namespace	M	1	Class	ESM required. Use file name (same as Resource title) or program name.
3	**Tile Identifier** MD_Metadata.identificationInfo.citation.CI_Citation.identifier.MD_Identifier.code	Identifier of the tile, when the NITF file is a tile or a member of a tile within a collection	C/ when the NITF file is a member of a tiled collection	1	String	When the NITF file comprises an entire tile, the file and the collection tile may have separate identifiers
4	**Resource Identifier Authority** MD_Metadata.identificationInfo.citation.CI_Citation.identifier.MD_Identifier.authority	party responsible for maintenance of the resource names	M	N	Class/CI_Citation	NMF required. Citation must include CI_Citation.title and CI_Citation.data (CI_Date) Use 'HRE Profile' and version date

	Name path	**Definition**	**Obligation**	**Max Occur**	**Data Type**	**Domain / Business Rule**
5	**Resource date** MD_Metadata.identificationInfo.citation.CI_Citation.date	reference date for the cited resource	M	N	Class <<DataType>>	CI_Date YYYY-MM-DD For dateType element, use code from http://metadata.ces.mil/mdr/ns/GSIP/codelist/DateTypeCode
6	**Collection Name** MD_Metadata.identificationInfo.citation.CI_Citation.series.CI_Series.name	Identifier of the collection, when the NITF file is a member of a tiled collection	C/ when the NITF file is a member of a tiled collection	1	String	A separate xml metadata instance shall be provided for the tiled collection (see Parent metadata file identifier)
7	**Resource originator** MD_Metadata.identificationInfo.pointOfContact	party that created the dataset	M	1	Class	CI_ResponsibleParty organizationName = value of NITF FH:OSTAID field role = originator
8	**Resource point of contact** MD_Metadata.identificationInfo.pointOfContact	party who can be contacted for inquiries regarding or acquisition of the dataset	M	1	Class	CI_ResponsibleParty organizationName = "US National Geospatial-Intelligence Agency" role = pointOfContact
9	**Resource Extents** MD_Metadata.MD_DataIdentification.extent.EX_Extent.geographicElement.EX_BoundingPolygon.polygon	Sets of points defining the bounding polygon	M	1	Class	GM_Object

	Name path	**Definition**	**Obligation**	**Max Occur**	**Data Type**	**Domain / Business Rule**
10	**Coordinate reference system - horizontal** MD_Metadata.referenceSystemInfo.MD_ReferenceSystem.referenceSystemIdentifier.RS_Identifier.codeSpace	identifier used for horizontal reference system	M	1	<<CodeList>>	Use value from http://metadata.ces.mil/mdr/ns/GSIP/crs For HRE Level 1: World Geodetic System 1984 - Geographic 2D For HRE Level 2-8: UTM Zone xx on WGS 84.
11	**Vertical extent minimum** MD_Metadata.identificationInfo.MD_DataIdentification.extent.EX_Extent.verticalElement.EX_VerticalExtent.minimuminmumValue	lowest vertical extent contained in the dataset	M	1	Real	Populate with lowest elevation value in the dataset
12	**Vertical extent maximum** MD_Metadata.identificationInfo.MD_DataIdentification.extent.EX_Extent.verticalElement.EX_VerticalExtent.maximuminmumValue	highest vertical extent contained in the dataset	M	1	Real	Populate with highest elevation value in the dataset
13	**Coordinate reference system - vertical** MD_Metadata.identificationInfo.MD_DataIdentification.extent.EX_Extent.verticalElement.EX_VerticalExtent.verticalCRS	1-dimension coordinate reference system used for recording heights or depths. Vertical CRSs make use of the direction of gravity to define the concept of height or depth, but the relationship with gravity may not be straightforward	M	1	<<CodeList>>	Value = entire URL of the CRS in the GSIP codelist: e.g. http://metadata.ces.mil/mdr/ns/GSIP/crs/WGS84E_3D (used for GPS Elevation, Geographic + Height Above Ellipsoid)
14	**Temporal extent** MD_Metadata.identificationInfo.MD_DataIdentification.extent.EX_Extent.temporalElement.EX_TemporalExtent.extent	date and time for the content of the dataset (collection date and time)	M	1	Class / TM_Primitive (ISO 19108)	YYYY-MM-DD

	Name path	**Definition**	**Obligation**	**Max Occur**	**Data Type**	**Domain / Business Rule**
15	**Coordinate reference system – temporal** MD_Metadata.referenceSystemInfo.MD_ReferenceSystem.referenceSystemIdentifier.RS_Identifier.codeSpace	Identifier used for temporal reference system	M	1	Character String	http://www.opengis.net/def/trs/ISO-8601/
16	**Resource language** MD_Metadata.identificationInfo.MD_DataIdentification.language	languages(s) used within the dataset	M	N	<<CodeList>>	Use value from http://metadata.ces.mil/mdr/ns/GPAS/codelist/iso639-2
17	**Resource character set** MD_Metadata.identificationInfo.MD_DataIdentification.characterSet	full name of the character coding standard used for the dataset	M	N	<<CodeList>>	Use value from http://metadata.ces.mil/mdr/ns/GSIP/codelist/CharacterSetCode
18	**Resource topic category** MD_Metadata.identificationInfo.MD_DataIdentification.topicCategory	main theme(s) of the dataset	M	N	Class / MD_TopicCategory	http://metadata.ces.mil/mdr/ns/GSIP/codelist/ResourceCategoryCode value = 'elevation'
19	**Distribution format** MD_Metadata.distributionInfo.MD_Distribution.distributionFormat.MD_Format	name of the data distribution format(s) and version of the format (date, number, etc.)	M	1	Aggregated Class	ESM Required. 'MIL-STD-2500C, National Imagery Transmission Format (Version 2.1), 1 May 2006'

	Name path	**Definition**	**Obligation**	**Max Occur**	**Data Type**	**Domain / Business Rule**
20	**Online Resource** MD_Metadata.distributionInfo.MD_Distribution.transferOptions.MD_DigitalTransferOption.onLine.CI_OnlineResource.linkage	location for online access to the resource	M	N	URL	ESM Required. URL for acquiring the dataset or for information on acquiring the dataset Default is https://nsgreg.nga.mil/doc/view?i=2065
21	**Resource representation form** MD_Metadata.identificationInfo.descriptiveKeywords.MD_Keywords.ThesaurusName.CI_Citation.title='NGMP_RepresentationFormCode'	Identification of the dataset as analog or digital	M	1	<<CodeList>>	ESM Required Value = 'digital'
22	**Resource Spatial Resolution (GSD)** MD_Metadata.identificationInfo.MD_DataIdentification.spatialResolution.MD_Resolution.distance	ground sample distance of the resource	M	1	Class / distance (ISO 19103)	Distance value is expressed as a real number. Unit of measure is decimal degrees for HRE Level 1, meters for HRE Levels 2-8. Note: see production-specific guidance for required precision.
23	**Resource Abstract** MD_Metadata.identificationInfo.abstract	brief narrative summary of the content of the resource(s)	M	1	Character String	*"*High Resolution Elevation (HRE) Data consisting of a fixed resolution grid of elevation values representing a geospatial surface*"* Note: additional information may be included here when deemed necessary by the producer
24	**Surface type** MD_Metadata.contentInfo.MD_ContentInformation.MD_CoverageDescription.attributeDescription	description of the attribute described by the measurement value	M	1	RecordType <<Metaclass>>	Character string Use "surface type = bare Earth" or "surface type = reflective surface"

	Name path	**Definition**	**Obligation**	**Max Occur**	**Data Type**	**Domain / Business Rule**
25	**Value type** MD_Metadata.contentInfo.MD_ContentInformation.MD_CoverageDescription.contentType	type of information represented by the cell value	M	1	Class	MD_CoverageContentTypeCode Use value 'physical measurement'
26	**Maintenance frequency** MD_Metadata.metadataMaintenance.MD_MaintenanceInformation.maintenanceAndUpdateFrequency	frequency with which changes and additions are made to the resource after the initial resource is completed	M	1	Class	MD_MaintenanceFrequencyCode Use codelist value Name (not numerical domain code)
27	**Dataset quality scope** MD_Metadata.DQ_DataQuality.scope	The specific data to which the data quality information applies	M	1	Class	DQ_Scope See section B.2
28	**Resource lineage** MD_Metadata.DQ_DataQuality.lineage	Non-quantitative quality information about the lineage of the data specified by the scope.	M	1	Association	LI_Lineage See section B.2
29	**Dataset quality report** MD_Metadata.DQ_DataQuality.report	Information related to the result of a quality evaluation of the dataset	M	N	Regulated Quality Element or Unregulated Quality Element (see B.2 for definition and minimum requirement)	DQ_Element See section B.2
30	**Spatial representation type** MD_Metadata.identificationInfo.MD_DataIdentification.spatialRepresentationType	method used to spatially represent geographic information	M	N	Class	MD_SpatialRepresentationTypeCode Use value 'grid'
31	**Metadata file identifier** MD_Metadata.fileIdentifier	unique identifier for the metadata file	M	1	Character String	Match the NITF file name '(NITF file name).xml'

	Name path	**Definition**	**Obligation**	**Max Occur**	**Data Type**	**Domain / Business Rule**
32	**Parent metadata file identifier** MD_Metadata.parentIdentifier	file identifier of the metadata to which this metadata is a subset (child)	C / if an upper hierarchy level exists	1	Character String	Free Text
33	**Metadata standard name** MD_Metadata.metadataStandardName	name of the metadata standard (including profile name) used	M	1	Character String	'NSG Metadata Foundation – Part 1'
34	**Metadata standard version** MD_Metadata.metadataStandardVersion	version (profile) of the metadata standard used	M	1	Character String	'2.0'
35	**Metadata language** MD_Metadata.locale.PT_Locale.language	language used for documenting metadata	M	1	Locale	'eng'
36	**Metadata character set** MD_Metadata.locale.PT_Locale.characterEncoding	full name of the character coding standard used for the metadata	M	1	Locale	'utf8'
37	**Metadata hierarchy level** MD_Metadata.hierarchyLevel	scope to which the metadata applies	M	N	<<CodeList>>	http://metadata.ces.mil/mdr/ns/GSIP/codelist/ScopeCode
38	**Metadata hierarchy level name** MD_Metadata.hierarchyLevelName	name of the hierarchy levels for which the metadata is provided	M	N	<<CodeList>>	http://metadata.ces.mil/mdr/ns/GSIP/codelist/ScopeAmplificationCode

	Name path	Definition	Obligation	Max Occur	Data Type	Domain / Business Rule
39	**Metadata point of contact** MD_Metadata.contact.CI_ResponsibleParty	identification of, and means of communication with, person(s) and organizations associated with the dataset	M	1	Class	organizationName = "US National Geospatial-Intelligence Agency" role = pointOfContact
40	**Metadata date stamp** MD_Metadata.dateStamp	date that the metadata was created	M	1	Class / Date	YYYY-MM-DD
41	**Rights** MD_Metadata.identificationInfo.resourceConstraints.MD_LegalConstraints.accessConstraints and MD_LegalConstraints.useConstraints	restrictions and legal prerequisites for accessing and using the resource or metadata	C / legal access/use constraints exist?	N	<<CodeList>>	Use value from http://metadata.ces.mil/mdr/ns/GSIP/codelist/RestrictionCode
42	**Security classification** MD_IdentificationInfo.resourceConstraints.MD_Constraints.MD_SecurityConstraints.classification	name of the handling restrictions on the resource	M	1	<<CodeList>>	Use value from http://metadata.ces.mil/mdr/ns/GSIP/codelist/ClassificationCode
43	**Security classification system** MD_IdentificationInfo.resourceConstraints.MD_Constraints.MD_SecurityConstraints.classificationSystem	name of the classification system for the resource	M	1	Character String	"US CAPCO"
44	**CAPCO Marking** MD_IdentificationInfo.resourceConstraints.MD_Constraints.MD_SecurityConstraints.NMF_SecurityConstraints.capcoMarking	provides Intelligence Community Information Security Markings (IC.ADD) security elements	M	1	Class	ISM_SecurityAttributesGroup See NSG Metadata Foundation (NMF) Part 1
45	**Keywords** MD_Metadata.identificationInfo.descriptiveKeywords.MD_Keywords.keyword	topic of the content of the resource. commonly used word(s) or formalized word(s) or phrase(s) used to describe the subject.	M	N	Character String	HRE Recommendation: 'DEM' or 'terrain' ('elevation' can also be used, but is already required as the value of the Resource Topic Category element)

	Name path	**Definition**	**Obligation**	**Max Occur**	**Data Type**	**Domain / Business Rule**
46	**Keyword thesaurus title** MD_Metadata.identificationInfo.descriptiveKeywords.MD_Keywords.thesaurusName.CI_Citation.title	name of the formally registered thesaurus or similar authoritative source of keywords	M	1	CharacterString	NMF required. The HRE recommendation is to cite ‘A to Z GIS: An Illustrated Dictionary of Geographic Information Systems’, which contains definitions of DEM, elevation, surface, terrain, and other relevant terms.
47	**Keyword thesaurus date** MD_Metadata.identificationInfo.descriptiveKeywords.MD_Keywords.thesaurusName.CI_Citation.date	reference date for the cited thesaurus	M	1	Class / CI_Date	For HRE recommended thesaurus (above): date is ‘2006’ Date Type Code is ‘revision’
48	**Instrument identification authority** MD_Metadata.MI_Metadata.MI_AcquisitionInformation.instrument.MI_Instrument.identifier.MD_Identifier.authority	party responsible for maintenance of the list of instrument (sensor) names	M	1	Class/CI_Citation	NMF required. Citation must include CI_Citation.title and CI_Citation.data (CI_Date)
49	**Instrument identification** MD_Metadata.MI_Metadata.MI_AcquisitionInformation.instrument.MI_Instrument.identifier.MD_Identifier.code	unique identification of the instrument used to collect the data	M	1	CharacterString	Manufacturer and model, if available. Otherwise, a program name, e.g. ‘Buckeye’.
50	**Instrument type** MD_Metadata.MI_Metadata.MI_AcquisitionInformation.instrument.MI_Instrument.type	Identification of the type of instrument (sensor)	M	1	CharacterString	e.g. ‘LIDAR’

B.2 Quality Metadata Requirements

Table B.1 includes the ISO DQ_DataQuality aggregated class of metadata. Only the first level of subelements in that class (scope, lineage and report) are listed. The DGIWG Elevation Surface Model and this HRE Profile require these subelements to be included in the XML metadata.

As of the publication date of this HRE Profile, the NMIS Part 2 schema had not accounted for NSG-specific requirements documented in the NMF Part 2: Quality Metadata. For full compliance with NSG metadata standards, data producers and interpreting systems must comply with both the ISO-based NMIS XML schema, and with any additional NSG-specific requirements documented in the NMF.

B.2.1 Scope and Lineage

The scope of the data quality information must be declared as either 'dataset' or a region of a dataset that has been subsetted based on quality. In the latter case, the region is identified by a number and its geographic extents. In the dataset case, only a lineage statement is required.

B.2.2. Quality Reports

Quality metadata for HRE data shall include reports on the completeness and absolute accuracy reports of the dataset. Both of these require quantitative results. The completeness percentage is reported via the ISO class DQ_CompletenessCommission. This class provides a means to define the rate of valid elevation values present in the dataset. The rate is expressed as an integer that represents a percentage. The absolute horizontal and vertical accuracy of the dataset are reported via the ISO class DQ_AbsoluteExternalPositionalAccuracy. The schema allows reports to include both qualitative and quantitative results of the accuracy measurement, and identification of the procedure used to derive the measurement.

Annex C provides descriptions of error propagation estimates including systematic, random, and relative error covariance by region, cross-region covariance, and random error covariance and scale factor per post. The NMIS XML schema includes all of the ISO elements necessary to provide detailed reports of error propagation, when required. Per post results can be provided using a NITF image segment that is referenced from the quality report. However, the NMF Part 2 does not yet address error propagation estimate reporting procedures. At the time of publication of this HRE Profile, sample XML files providing an NSG recommended practice for documenting this metadata were in development (TBD).

Annex C HRE Metadata in support of Error Propagation

C.1 Overview

This annex provides insight into the metadata architecture that allows rigorous error propagation of HRE data. The first subsection describes how error covariance data is to be stored. The second subsection describes how an exploitation tool would use the HRE metadata. The explanation and examples pertain specifically to lidar; however they can be extended to apply to other systems such as IFSAR and stereo optical. The principles recommended below are described in terms of points (relevant to a future HRE spec) and full covariance matrices, but would apply also to the special case of posts (relevant to the current HRE spec).

The use of high resolution elevation data for tasks that require a specified level of geolocation accuracy necessitates the need for data to estimate these errors anywhere within the elevation data coverage area. This information is to be documented in the XML DES or, when grid coverage results are required, in a combination of the XML DES and one or more NITF image segments.

The suggested implementation specifies how to provide the uncertainty data needed to compute estimated horizontal and vertical errors (both absolute and relative) for each post in the associated high resolution elevation image segment. Various options are defined to specify the rigorous error propagation for each post in the associated HRE DTEM image segment. Options are provided for defining N distinct regions, so that region and cross-region systematic error and relative error covariance data may be specified. Options are also provided for assigning the random error component of covariance data for each post in the DTEM or defining nominal random error component covariance data for each region that can then be scaled to unique covariance matrices for each post in the DTEM via per-post random error scale factors. In general, specifying the covariance data for N regions will result in less metadata being required for rigorous error propagation, at the possible expense of fidelity.

As geolocation accuracy requirements become more stringent, assigning a single value of horizontal and vertical error for an entire DEM becomes an unsatisfactory solution. Therefore, this profile defines a metadata structure that permits rigorous, high fidelity error estimates to be computed on a post-by-post basis. This is accomplished by defining the fields needed to specify the covariance data for an accompanying data set. Standard error propagation techniques (i.e., linear combinations of Gaussian random variables) may then be used to compute a unique 3 by 3 covariance matrix for each post in the data set.

This profile outlines how to define one or more regions and three types of covariance data (systematic, relative and random). The regions are intended to define areas with different error propagation characteristics. With this data a complete set of error propagation covariance data may be specified for each region and for each post. An illustration of regions defined to cover an HRE grid is contained in Figure C-1.

The types of data needed to define the error propagation data is illustrated in Figure C-2. For the systematic error, "σ_x" represents the predicted systematic error per component within a region, and "$\zeta_{r,c}$" is the correlation coefficient between components, "Σ_{GX}" represents the systematic error for region X, and "Σ_G" is the full cross-region covariance matrix. Relative error between points within a region can be computed given the distance between two points and the matrices, "Φ_U" and "Φ_V" that express the increase in covariance magnitude per meter. For the random error, "σ_x" represents the predicted random error per component at a post and "$\zeta_{r,c}$" is the correlation coefficient between components. When the random error covariance is defined per region: Random Error Covariance per Post is calculated by:

$$\Sigma_{R(\square r,c)} = \Sigma_{RX} * SF_{r,c}$$

Where, $\Sigma_{R(\square r,c)}$ is the random error per post, Σ_{RX} is the random error covariance per region, and $SF_{r,c}$ is a per post scale factor.
DTEM regions may be specified point-by-point. In this case, for each post in the DTEM, a region number is assigned, from 001 to 256. This post-by-post region assignment information is provided in a separate image segment within the same NITF file as the DTEM post data. Indexing into this image segment is identical to indexing into the DTEM post image segment. Every post in the DTEM must be assigned to a region. This option provides the most flexibility for defining region geometries.

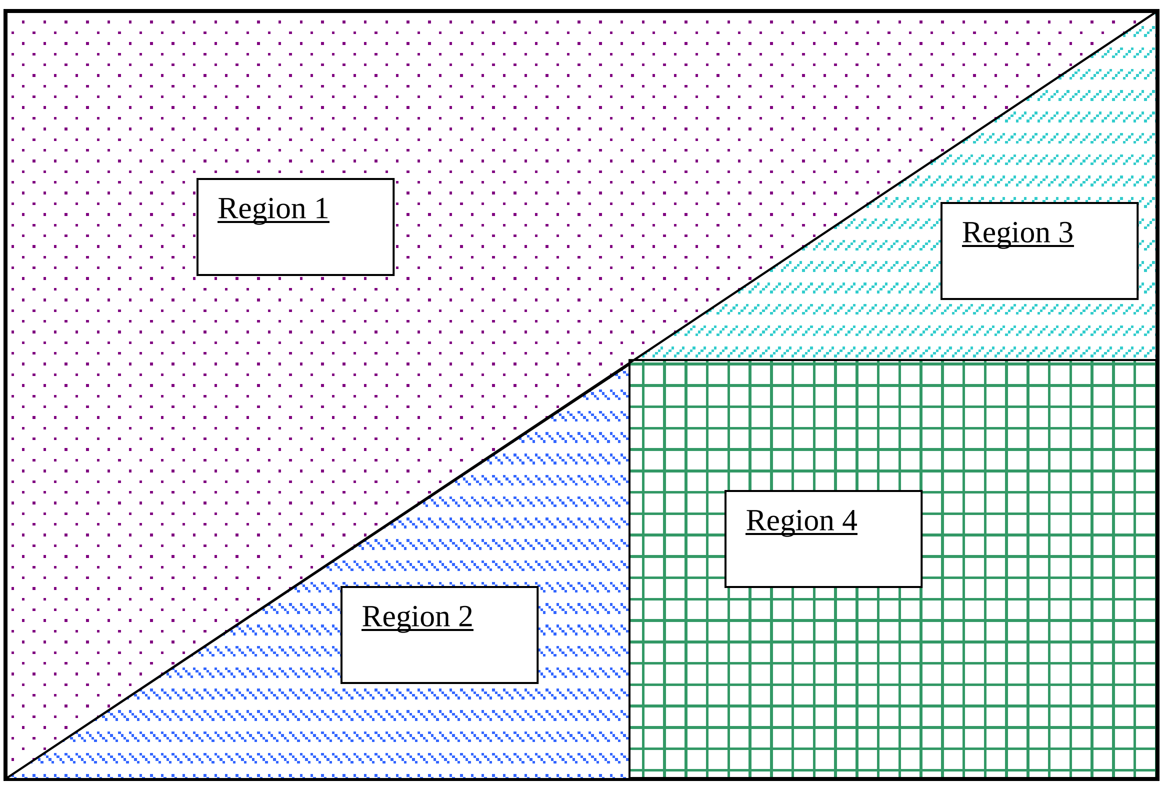


Figure C-1 Example defining regions for a sample DEM area. The regions need not be square, nor all of the same size.

Stored Per Region in XML DES		**Stored Per Post in Image Segments**
Regions defined by polygon vertices	<- OR ->	Regions defined per post (NITF image subheader IID1 field = "EP_REGIONS")

Systematic Error per region: $\Sigma_{GX} = \begin{bmatrix} \sigma_1{}^2 & \sigma_1\sigma_2\zeta_{12} & \sigma_1\sigma_3\zeta_{13} \\ & \sigma_2{}^2 & \sigma_2\sigma_3\zeta_{23} \\ & & \sigma_3{}^2 \\ symmetric & & \end{bmatrix}$	<- ONLY	
Cross-Region Systematic Error: $\Sigma_G = \begin{bmatrix} \Sigma_{G1} & \Sigma_{G12} & \Sigma_{G13} & \Sigma_{G14} \\ & \Sigma_{G2} & \Sigma_{G23} & \Sigma_{G24} \\ & & \Sigma_{G3} & \Sigma_{G34} \\ symmetric & & & \Sigma_{G4} \end{bmatrix}$	<- ONLY	
Region Relative Error: $\Phi_U = \begin{bmatrix} \frac{d\sigma^2_x}{du^2} & \frac{d\sigma_{xy}}{du^2} & \frac{d\sigma_{xz}}{du^2} \\ & \frac{d\sigma^2_y}{du^2} & \frac{d\sigma_{yz}}{du^2} \\ Symmetric & & \frac{d\sigma^2_z}{du^2} \end{bmatrix}$ $\Phi_V = \begin{bmatrix} \frac{d\sigma^2_x}{dv^2} & \frac{d\sigma_{xy}}{dv^2} & \frac{d\sigma_{xz}}{dv^2} \\ & \frac{d\sigma^2_y}{dv^2} & \frac{d\sigma_{yz}}{dv^2} \\ Symmetric & & \frac{d\sigma^2_z}{dv^2} \end{bmatrix}$ `rotationAngle, thresholdDistance`	<- ONLY	
Random Error per region $\Sigma_{RX} = \begin{bmatrix} \sigma_1{}^2 & \sigma_1\sigma_2\zeta_{12} & \sigma_1\sigma_3\zeta_{13} \\ & \sigma_2{}^2 & \sigma_2\sigma_3\zeta_{23} \\ & & \sigma_3 \\ symmetric & & \end{bmatrix}$	AND	Random Error scale factor per post: Scale Factor per post ("RE_POST_SF")
	OR	
	ONLY ->	Random Error per post: $\Sigma_{R(r,c)} = \begin{bmatrix} \sigma_1{}^2 & \sigma_1\sigma_2\zeta_{12} & \sigma_1\sigma_3\zeta_{13} \\ & \sigma_2{}^2 & \sigma_2\sigma_3\zeta_{23} \\ & & \sigma_3{}^2 \\ symmetric & & \end{bmatrix}$ (NITF image subheader IID1 field = "COVARIANCE" and "COREL_COEF")

Figure C-2. Examples of the types of covariance matrix data needed for rigorous error propagation. The types of data are organized on the left or right depending on whether the data appears in the XML DES or in an image segment.

As an alternative, DTEM regions may be specified by polygons. This option permits defining regions via polygon vertex coordinate pairs. Each region may consist of from 3 up to 999 coordinate pairs to accurately portray its outline. In addition:

- Coordinate pairs defining a region must be arranged in a clockwise direction.

- Each region coordinate pair must be located on or within the bounding rectangle. The IGEOLO field in the DTEM image sub header defines the bounding rectangle.
- Region areas must not overlap or leave gaps. Region areas must cover the entire HRE DTEM.
- The first and last coordinate pairs of a region shall be the same. Closure of the region is not implied.

Options are defined to place the HRE covariance data wholly within the XML DES, or a mixture of XML DES and NITF image segments that accompany the DTEM image segment in the same NITF file. Two types of covariance data need to be specified. The first, systematic error covariance is always defined within the XML DES. Provision is made to specify the covariance elements for each region, as well as, cross-region covariance elements. The second, random error covariance is specified through a combination of data specified within the XML DES and in one or more image segments. XML DES parameters reference the specific image segments, as needed.

The covariance elements for systematic and random errors are specified via standard deviations for the diagonal terms, and correlation coefficients for the off-diagonal terms. The actual off-diagonal covariance elements are then computed by multiplying the correlation coefficients with the appropriate, diagonal, standard deviation terms. The diagonal variance terms are computed by squaring the corresponding standard deviations. The covariance elements for relative error are specified as changes in variance.

C.2 Metadata Contents

C.2.1 Define Regions

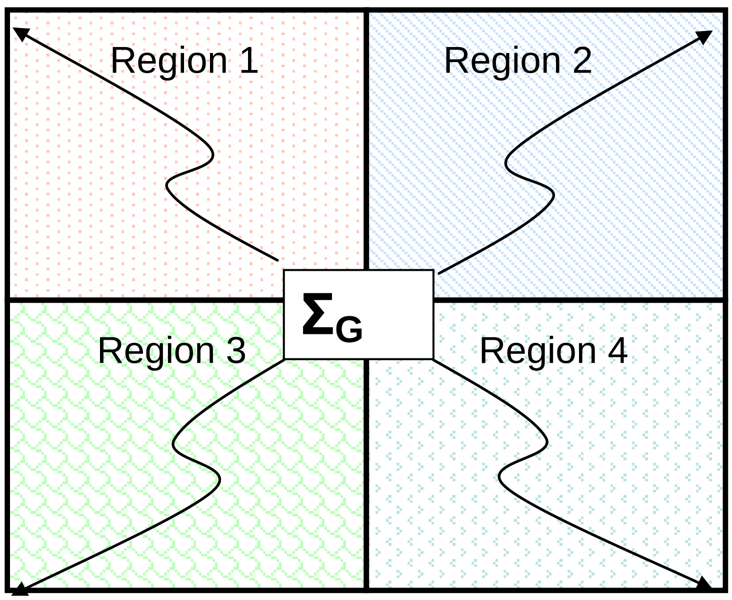
The vendor shall partition the entire HRE product into N distinct regions (one or more) based on data error characteristics. HRE provides 2 methods for partitioning into regions; (1) to define a raster grid of positive integers that identify a post as belonging to one of the N regions; or (2) specify the X,Y coordinates of each vertex defining each of the N polygons or regions, assuring that the edges of adjacent polygons are coincident and there are not any gaps or overlaps between regions.

C.2.2 Provide Cross-Region Systematic Error Covariance Data

Consider for example a HRE product requiring the division into four regions (see Figure C-3). Our objective is to specify a full covariance matrix that represents the typical covariance and correlation information associated with multiple ground points appearing across different regions. Then, Equation 1 is the full covariance matrix that shall be provided as metadata:

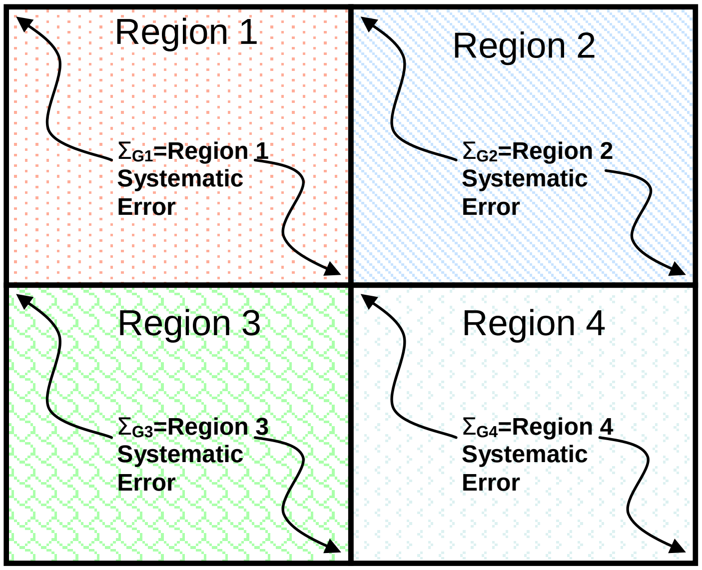
$$\underset{12\times 12}{\Sigma_G} = \begin{bmatrix} \Sigma_{G1} & \Sigma_{G12} & \Sigma_{G13} & \Sigma_{G14} \\ & \Sigma_{G2} & \Sigma_{G23} & \Sigma_{G24} \\ & & \Sigma_{G3} & \Sigma_{G34} \\ symmetric & & & \Sigma_{G4} \end{bmatrix} \quad (1)$$

In the lidar example, the full ground points covariance matrix, Σ_G, consisting of 3 by 3 sub-matrices, can be calculated by performing rigorous error propagation on a set of three condition equations per object point in which observations consist of: a pair of direction angles, a range measurement, and all sensor parameters. The vendor should calculate the covariance matrix to correspond to ground points located at the approximate centers of their associated regions (see Figure C-4). The full simultaneous error propagation must take into account the correlation between sensor parameters in different strips. Also, the input covariance information should exclude high-frequency noise, i.e. random error, which will be handled separately. The availability of a sensor model for the collection system that is compliant with the Community Sensor Model (CSM) standard would allow for such error propagation.



$$\underset{12\times 12}{\Sigma_G} = \begin{bmatrix} \Sigma_{G1} & \Sigma_{G12} & \Sigma_{G13} & \Sigma_{G14} \\ & \Sigma_{G2} & \Sigma_{G23} & \Sigma_{G24} \\ & & \Sigma_{G3} & \Sigma_{G34} \\ \mathit{symmetric} & & & \Sigma_{G4} \end{bmatrix}$$

Figure C-3 Full covariance data for the systematic errors of four regions



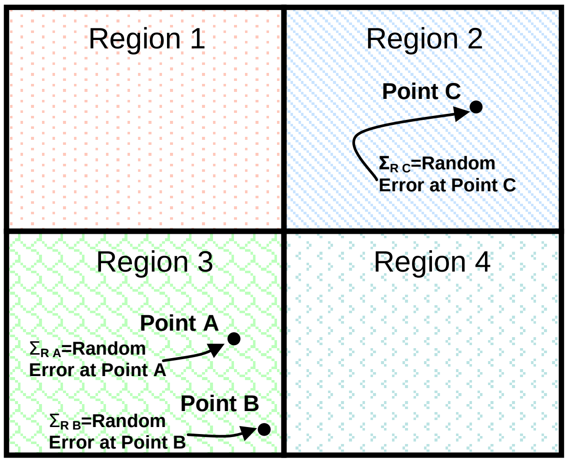
$$\Sigma_{G,R\#} = \begin{bmatrix} \sigma_1^2 & \sigma_1\sigma_2\zeta_{12} & \sigma_1\sigma_3\zeta_{13} \\ & \sigma_2^2 & \sigma_2\sigma_3\zeta_{23} \\ & & \sigma_3^2 \end{bmatrix}$$

Figure C-4 Systematic Error ($\Sigma_{G,R\#}$) per Region where R# represents a Region Number and the DEM consists of four regions (1-4)

C.2.3 Provide Random Covariance Data

The random component of predicted error shall be handled on a point by point basis. Following are two strategies to consider: 1) for each point store all 6 independent values required to express a 3 by 3 ground covariance matrix; or 2) for each of the N regions specify the 6 independent values required to express a nominal 3 by 3 random-component ground covariance matrix, and then for each point in the dataset store a scalar value necessary to scale the nominal 3 by 3 ground covariance matrix to arrive at the desired per point values (see Figure C-5).

Strategy 1 will take a large amount of storage space. Strategy 2 is an approximation that will only be valid for narrow field-of-view (i.e., except for a scale factor, the characteristics of the 3D error volume are well modeled by the nominal covariance matrix everywhere in the region). Note that the availability of a CSM compliant model would allow for calculation of the 3 by 3 ground covariance matrix at each point.



$$\Sigma_{R_{(r,c)}} = \begin{bmatrix} \sigma_1^2 & \sigma_1\sigma_2\zeta_{12} & \sigma_1\sigma_3\zeta_{13} \\ & \sigma_2^2 & \sigma_2\sigma_3\zeta_{23} \\ \textit{symmetric} & & \sigma_3^2 \end{bmatrix}$$

For each Point (P) from 1…n

OR

$$\Sigma_{R,R\#} = \begin{bmatrix} \sigma_1^2 & \sigma_1\sigma_2\zeta_{12} & \sigma_1\sigma_3\zeta_{13} \\ & \sigma_2^2 & \sigma_2\sigma_3\zeta_{23} \\ \textit{symmetric} & & \sigma_3^2 \end{bmatrix}$$

For each Region (R#) and then scale for each point (P)

$$\Sigma_{R_{(r,c)}} = \Sigma_{R,R\#} * SF_{(r,c)}$$

Where $SF_{P(r,c)}$ is a scale factor per point

Figure C-5 The random error (Σ_R) at a point (P)

C.2.4 Provide Relative Covariance Data within a Region

The precision of the relative vector between two points, A and B, appearing within the same region should vary as a function of the horizontal vector between the two points:

$$\Sigma_{AB} = \Sigma_{RA} + \Sigma_{RB} + D_U^2 \cdot \Phi_U + D_V^2 \cdot \Phi_V \quad (2)$$

Where $\Sigma_{randomA}, \Sigma_{randomB}$ are the 3 by 3 matrices, as per Section C.2.3, expressing the random error at each point; D_U, D_V represent the horizontal distances in meters between the two points in a local coordinate system that has been rotated from the UTM cartesian coordinate system of the dataset (see Figure C-4); and Φ_U, Φ_V are 3 by 3 matrices expressing the increase in covariance magnitude per meters squared point separation squared (measured in meters squared) along the U and V axes. As illustrated in the example below, the local (U-V) space is necessary to provide the flexibility to account for covariance growth resulting from the data collection / generation that may not occur parallel to the UTM coordinate system. A maximum distance can also be specified such that the determinant of Σ_R do not exceed specified maximums.

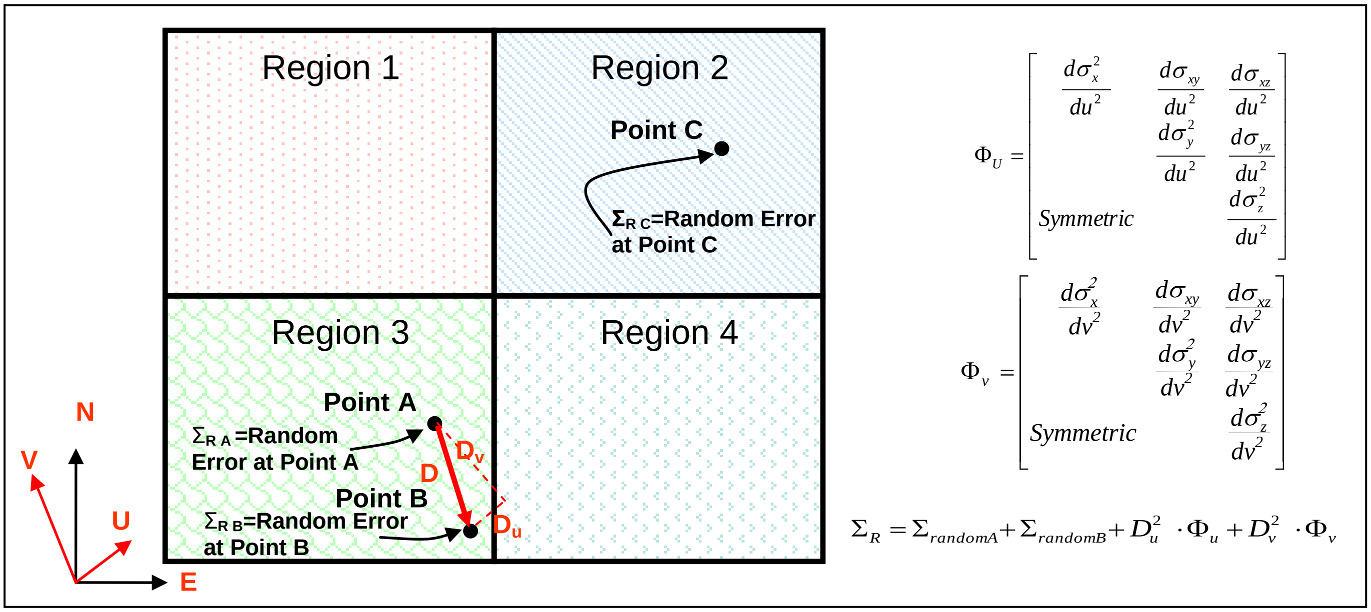


Figure C-6 Relative covariance of vector R within a region (region 3 in this case)

As an example of how a vendor would calculate the Φ_U, Φ_V matrices to provide in the HRE metadata, consider an airborne lidar platform flying along the *U* axis and scanning perpendicular to the *U* axis in the *V* direction. Then, using rigorous error propagation facilitated by CSM function calls, the vendor can calculate the covariance matrices of the vectors between pairs of points as a function of their separation distances in the *U* and *V* directions, i.e. D_U, D_V. The vendor would solve for the increase in covariance magnitude per meters squared, Φ_U, Φ_V, assuming that relative error increases linearly as follows:

$$\Sigma_{AB} = \Sigma_{RA} + \Sigma_{RB} + D_U^2 \cdot \Phi_U + D_V^2 \cdot \Phi_V \qquad (3)$$

Given that a counterclockwise rotation angle of θ rotates the X axis (about the Z, or up, axis) to align with the U axis, we can apply the changes associated with Φ_U, Φ_V using the ground distances (D_X, D_Y) and the following equation:

$$\Sigma_{AB} = \Sigma_{RA} + \Sigma_{RB} + \Phi_U (D_X \cos\theta + D_Y \sin\theta)^2 + \Phi_V (-D_X \sin\theta + D_Y \cos\theta)^2 \; (4)$$

C.2.5 Error data discussion

To help clarify the error data discussed above, consider a derivation of the results just presented. Imagine that data points of interest are segregated into non-overlapping geographic regions. Let each region be designated by the letter 'G' followed by a unique number. Let each point within a region be designated by the same region designation followed by a unique lowercase alphabetic label (e.g. we have point a in region G1, also designated as G1a). We are interested in the errors in spatial position of such data points.

Let $\mathbf{P}_{G1a}$ be a 3D vector specifying the position of point G1a in a suitable reference frame. Express $\mathbf{P}_{G1a}$ as the sum of a vector that specifies the position of region G1 (designated as $\mathbf{S}_{G1}$) and a 3D vector that gives the position of point G1a relative to $\mathbf{S}_{G1}$ (designate this vector as $\mathbf{r}_{G1a}$). Then

$$\mathbf{P}_{G1a} = \mathbf{S}_{G1} + \mathbf{r}_{G1a} \qquad (5)$$

The quantities in equation (5) are all subject to errors. Designate the deviation from the mean of any quantity i with the symbol (δ). Then

$$\delta\mathbf{P}_{G1a} = \delta\mathbf{S}_{G1} + \delta\mathbf{r}_{G1a} \qquad (6)$$

Now we can identify the errors $\delta\mathbf{S}_{G1}$ with the systematic errors in section **C.2.2**, and the errors $\delta\mathbf{r}_{G1a}$ with the random errors in section **C.2.3**.

Three by three covariance matrices between a pair of 3D vectors can be written as,

$$\boldsymbol{\Sigma}_{GIGJ} \equiv \langle \, \delta\mathbf{S}_{GI} \quad \delta\mathbf{S}^{T}{}_{GJ} \, \rangle \qquad (7)$$

Where the brackets denote expectation value and $\mathbf{S}^T$ indicates the transpose (a row vector) of the column vector **S**, so that the product in (7) is an outer product. As written, equation (7) gives the covariances for the systematic errors $\delta\mathbf{S}_{GI}$ and $\delta\mathbf{S}_{GJ}$. If the terms for region numbers I ≠ J are non-zero, it indicates that the errors in specifying the location of region I are not independent of the errors in locating region J. If the set of covariance matrices for N regions are gathered into a 3N x 3N matrix, the result is equation (1), in section **C.2.2**.

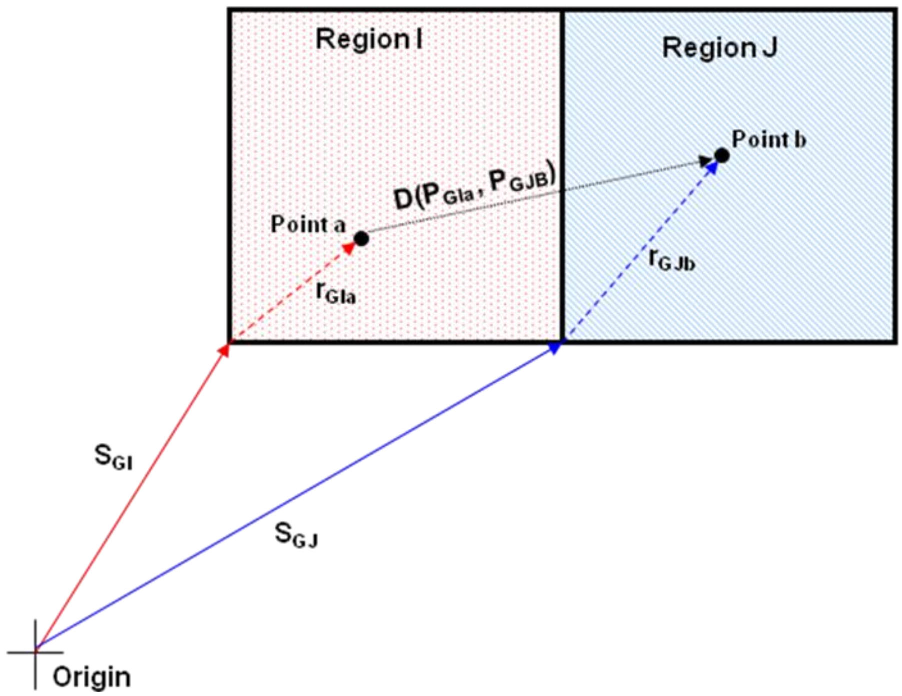


Figure C-7 Systematic and Random Error Vector Representation

Now consider the covariance matrix between a vector locating point GIa, $\mathbf{P}_{GIa}$, and a vector locating point GJb, $\mathbf{P}_{GJb}$. This can be written as

$$\Sigma(\mathbf{P}_{\mathbf{GIa}}\mathbf{P}_{\mathbf{GJb}}) \equiv \langle\, \delta\mathbf{P}_{GIa} \quad \delta\mathbf{P}^{T}_{GJb} \,\rangle \equiv \Sigma_{\mathbf{GIGJ}} + \Sigma_{\mathbf{GIaGJb}} + \Sigma_{\mathbf{GIGJb}} + \Sigma_{\mathbf{GIaGJ}} \quad (8)$$

The four terms on the right are obtained by using equation (6) in the middle expression in (8), expanding out the product and denoting the individual product terms as covariance matrices using notation to differentiate between systematic and random error terms. The first of the terms on the right is defined by equation (7), the second is a similar expression for covariances between random errors, and the third and fourth terms involve covariances between systematic errors and random errors. Here, the definition of separate regions implies that covariances of random errors across regions are zero ($\Sigma_{\mathbf{GIaGJb}} \equiv 0$, $I \neq J$) and that the covariances of random errors with systematic errors are always zero. With these assumptions equation (8) becomes:

$$\Sigma(\mathbf{P}_{\mathbf{GIa}}\mathbf{P}_{\mathbf{GJb}}) = \Sigma_{\mathbf{GIGJ}} \qquad I \neq J \quad (9)$$

$$\Sigma(\mathbf{P}_{\mathbf{GIa}}\mathbf{P}_{\mathbf{GJb}}) = \Sigma_{\mathbf{GIGI}} + \Sigma_{\mathbf{GIaGIb}} \quad I = J \quad (10)$$

If a = b, equation (10) is essentially equation (15) in section **C.3.1**. Taken together, equations (9) and (10) are used in the formulation of equation (16) in section **C.3.1**.

Finally, consider the covariances for a vector connecting two points (so that we may arrive at an expression for the relative error between two points). Let the vector from point $\mathbf{P}_{\mathbf{G}Jb}$ to point $\mathbf{P}_{\mathbf{G}Ia}$ be denoted as $\mathbf{D}(\mathbf{P}_{\mathbf{G}Ia}\mathbf{P}_{\mathbf{G}Jb}) \equiv \mathbf{P}_{\mathbf{G}Ia} - \mathbf{P}_{\mathbf{G}Jb}$. Then the error in **D** is

$$\delta\,\mathbf{D}(\mathbf{P}_{\mathbf{G}Ia}\mathbf{P}_{\mathbf{G}Jb}) = \delta\,\mathbf{P}_{\mathbf{G}Ia} - \delta\,\mathbf{P}_{\mathbf{G}Jb} \qquad (11)$$

And the covariance matrix among the components of **D** is

$$\Sigma_D(GIa,GJb) = \langle\, (\delta\,\mathbf{P}_{\mathbf{G}Ia} - \delta\,\mathbf{P}_{\mathbf{G}Jb})\,(\delta\,\mathbf{P}_{\mathbf{G}Ia} - \delta\,\mathbf{P}_{\mathbf{G}Jb})^T \,\rangle \qquad (12)$$

$$= \langle\, (\delta\mathbf{S}_{GI} - \delta\mathbf{S}_{GJ} + \delta\mathbf{r}_{GIa} - \delta\mathbf{r}_{GJb})\,(\delta\mathbf{S}_{GI} - \delta\mathbf{S}_{GJ} + \delta\mathbf{r}_{GIa} - \delta\mathbf{r}_{GJb})^T\rangle$$

If I = J (the endpoints of D are both in the same region) then

$$\Sigma_D(GIa,GJb) = \langle\, (\delta\mathbf{r}_{GIa} - \delta\mathbf{r}_{GIb})\,(\delta\mathbf{r}_{GIa} - \delta\mathbf{r}_{GIb})^T\rangle \qquad (13)$$

$$= \Sigma_{\mathbf{G}Ia\mathbf{G}Ja} + \Sigma_{\mathbf{G}Ib\mathbf{G}Ib} - \Sigma_{\mathbf{G}Ia\mathbf{G}Jb} - \Sigma_{\mathbf{G}Ib\mathbf{G}Ja}$$

This agrees with equation (2) in section C.2.4 if we identify the last two terms in equation (13) with $D_U^2\Phi_U + D_V^2\Phi_V$ in equation (2). Equation (13) is the more general form and equation (2) was chosen as a way to provide a simplified approach to specifying the cross-covariance terms in the HRE metadata.

If I ≠ J (the endpoints of **D** are in different regions) then the right hand side of equation (12) comprises sixteen terms. If, however, we again assume that covariances of random errors across regions are zero, and that covariances of random errors with systematic errors are zero, (12) becomes

$$\Sigma_D(GIa,GJb) = (\Sigma_{\mathbf{G}I\mathbf{G}I} + \Sigma_{\mathbf{G}Ia\mathbf{G}Ia}) + (\Sigma_{\mathbf{G}J\mathbf{G}J} + \Sigma_{\mathbf{G}Jb\mathbf{G}Jb}) - \Sigma_{\mathbf{G}I\mathbf{G}J} - \Sigma_{\mathbf{G}J\mathbf{G}I} \qquad (14)$$

This is essentially equation (17) below in section **C.3.2.1**.

C.3 Exploitation

Figure C-6 illustrates a simple example where two points of interest, A and C, appear in different regions. The first sub-section illustrates how an exploitation tool reconstructs a full covariance matrix containing the covariance matrices for points A and C and the joint cross covariance between points A and C. The second sub-section illustrates how an exploitation tool calculates the precision, expressed as a full covariance matrix, of the relative vector between points A and C.

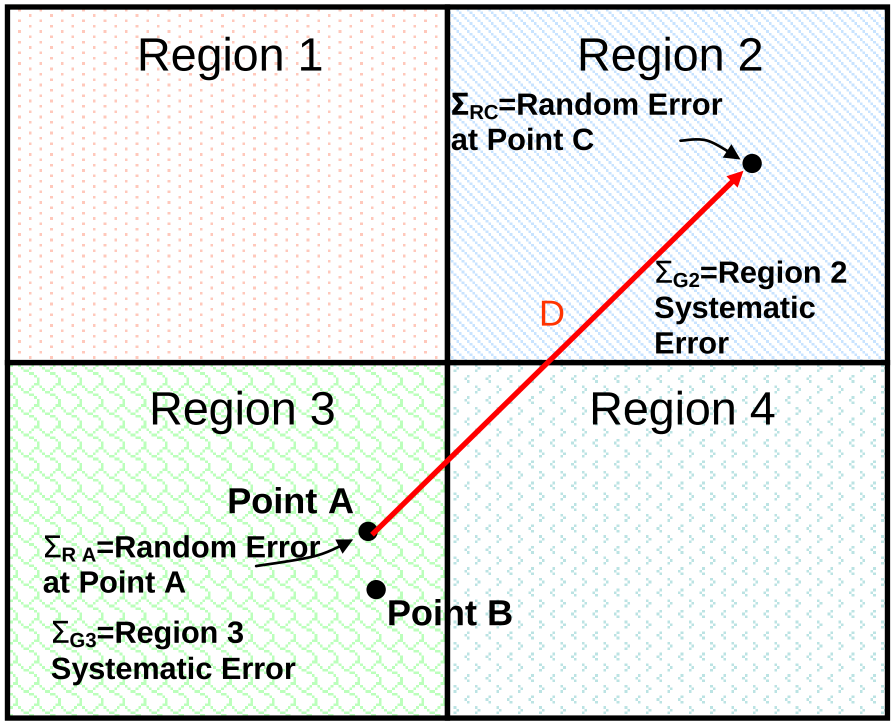


Figure C-8 Sample DEM footprint consisting of four regions with vector crossing regions

C.3.1 Reconstruction of Full Covariance Matrix for a Single Point

Consider point A in region 3. Then, following is the equation for the full 3 by 3 covariance matrix for point A:

$$\Sigma_{AA} = \left(\Sigma_{G3} + \Sigma_{RA}\right) \qquad (15)$$

C.3.2 Reconstruction of Full Covariance Matrix for Multiple Points

The full 6 by 6 covariance matrix for points A and C is constructed as follows:

$$\Sigma_{AC} = \begin{bmatrix} \Sigma_{G3} + \Sigma_{RA} & \Sigma_{G23} \\ \Sigma_{G23}^{T} & \Sigma_{G2} + \Sigma_{RC} \end{bmatrix} \qquad (16)$$

Where Σ_{RA}, Σ_{RC} are the random components of precision for points A and C.

C.3.2.1 Construct Covariance Matrix for Relative Error

Let D denote the relative vector from A to C. Then, following is the equation for the full 3 by 3 covariance matrix for vector D:

$$\Sigma_{DD} = \left(\Sigma_{G3} + \Sigma_{RA}\right) + \left(\Sigma_{G2} + \Sigma_{RC}\right) - \Sigma_{G23} - \Sigma_{G23}^{\ \ T} \quad (17)$$

C.3.2.2 Random Error Covariance at a Point

Consider the case where we would like to isolate the random error covariance at a point (point A) without trying to isolate the system observations that contribute solely to random error. We can calculate the full covariance matrix for points A and B, where B is very close to A, and both A and B have the same precision. Then, we can break this full 6 by 6 matrix down to determine the random component of precision at point A, expressed as a full 3 by 3 matrix as follows:

$$\Sigma_{RA} \cong \frac{1}{2}\left(\Sigma_{AA} + \Sigma_{BB} - \Sigma_{AB} - \Sigma_{AB}^{\ \ T}\right) \qquad (18)$$

C.3.2.3 Computing the Absolute Error at a Point

One of the common applications of the uncertainty data is to predict the absolute error of a point. This could be performed to determine the absolute accuracy of a single point or it may be an operation where the absolute accuracy of every DEM post is determined to develop a grid of uncertainties for additional visualization / exploitation.
The first step to developing the absolute accuracy is to combine the systematic and random uncertainty estimates for the point(s) of interest as shown in Figure C-9 below.

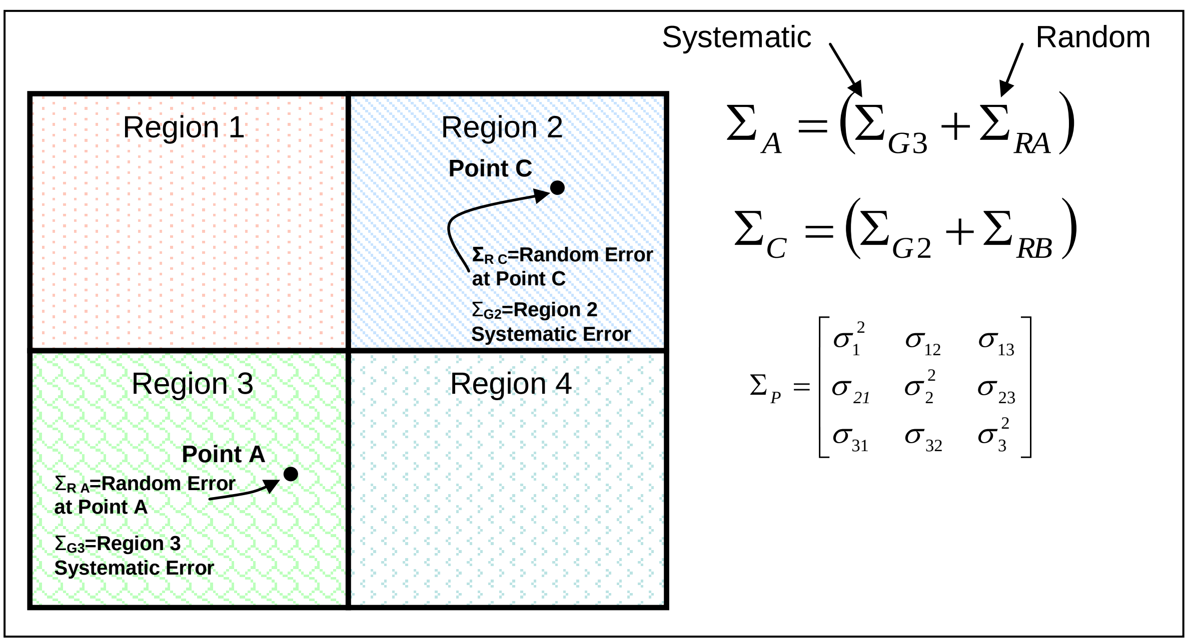


Figure C-9 Covariance data at a point

Once developed the covariance matrix (Σ_P) represents the uncertainty around the point (P). If one were solely interested in the horizontal uncertainty of point P, only the 2x2 covariance elements related to horizontal uncertainty would be evaluated and these would represent an error ellipse of uncertainty around point P (See Figure C-10).

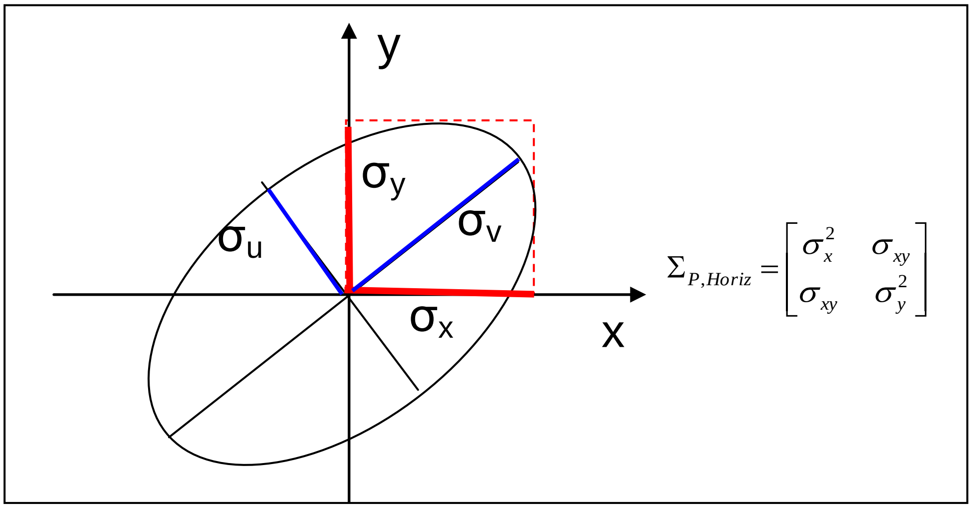


Figure C-10 Horizontal Error ellipse at a point

Using the values of the error ellipse, one can also calculate a circular error for the point (P) at a given confidence interval (see Figure C-11). There are several documented methods to calculate the CE90 using the covariance data. In this case, the method proposed in Department of Defense Standard Practice: Mapping, Charting, and Geodesy Accuracy [MIL-STD-600001] is shown.
First compute the eigenvalues of the ellipse:

$$\sigma_u^2 = \frac{\sigma_x^2 + \sigma_y^2}{2} + \sqrt{\frac{1}{4}\left(\sigma_x^2 - \sigma_y^2\right)^2 + \left(\sigma_{xy}\right)^2}$$

$$\sigma_v^2 = \frac{\sigma_x^2 + \sigma_y^2}{2} - \sqrt{\frac{1}{4}\left(\sigma_x^2 - \sigma_y^2\right)^2 + \left(\sigma_{xy}^2\right)}$$

Then compute the ratio between them:

$$C = {}^{\sigma_v}\!/_{\sigma_u}$$

Finally, calculate the CE:

$$CE90=(1.6545 – 0.13913C + 0.6324C^2)\sigma_u$$

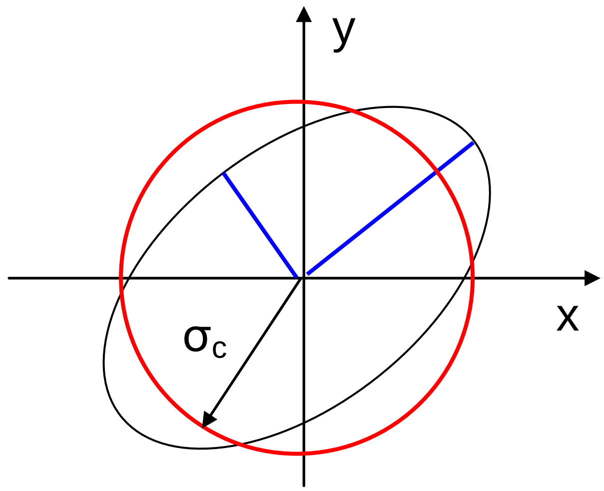


Figure C-11 Circular error from covariance data

In a similar fashion, the covariance element for the variance in the vertical or z direction also be used to calculate the vertical uncertainty of a point at a given confidence interval. To calculate the LE90 of a point (P), one would calculate:

$$LE90_{ABS,P} = 1.6449\sigma_z$$